MAN123.GRNDWTRMONITSAP

Sampling and Analysis Plan
for
Groundwater Monitoring
at the
Property Utilization and Disposal
(PU&D) Yard

Draft Final

July 2000
Revision 0

1/46

Sampling and Analysis Plan for Groundwater Monitoring at the Property Utilization and Disposal (PU&D) Yard

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Revision 0

Effective Date: July 10, 2000

This Sampling and Analysis Plan has been reviewed and approved by:

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ACRONYMS and ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
ALF	Action Level Framework
Am	americium
ASD	Analytical Services Division
CDPHE	Colorado Department of Public Health and the Environment
DCE	dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquid
DOE	U. S. Department of Energy
DQO	Data Quality Objective
EDD	Electronic Disc Deliverable
EPA	Environmental Protection Agency
FID	flame ionization detector
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FO	Field Operations
ft	foot, feet
g	gram
gpm	gallons per minute
HSS	Health and Safety Specialist
HRR	Historical Release Report
ID	inside diameter
IHSS	Individual Hazardous Substance Site
IMP	Integrated Monitoring Plan
Kg	kilogram
KH	Kaiser-Hill
L	liter
LHSU	Lower Hydrostratigraphic Unit
µg	microgram
mg	milligram
OU	Operable Unit
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCi	picoCurie
PID	photoionization detector
PM	project manager
PU&D	property utilization and disposal
Pu	plutonium
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Program
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RIN	report identification number
RMRS	Rocky Mountain Remediation Services, L.L.C.

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ACRONYMS and ABBREVIATIONS (Cont')

RPD	relative percent difference
RWP	Radiological Work Permit
SAP	Sampling and Analysis Plan
SWD	Soil and Water Database
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TDS	total dissolved solids
UHSU	Upper Hydrostratigraphic Unit
VOC	volatile organic compound

LIST OF APPLICABLE STANDARD OPERATING PROCEDURES (SOPs)

Identification Number	Procedure Title
RF/RMRS-98-200	*Evaluation of Data for Usability in Final Reports*
2-S47-ER-ADM-05.14	*Use of Field Logbooks and Forms*
RMRS/OPS-PRO.070	*Decontamination of Equipment at Decontamination Facilities*
4-S01-ENV-OPS-FO.03	*Field Decontamination Procedures*
RMRS/OPS-PRO.128	*Handling of Purge and Development Water*
RMRS/OPS-PRO.112	*Handling of Decontamination Water and Wash Water*
RMRS/OPS-PRO.069	*Containing, Preserving, Handling and Shipping of Soil and Water Samples*
5-21000-OPS-FO.15	*Photoionization Detectors and Flame Ionization Detectors*
5-21000-OPS-FO.16	*Field Radiological Measurements*
RMRS/OPS-PRO.101	*Logging Alluvial and Bedrock Material*
RMRS/OPS-PRO.114	*Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*
RMRS/OPS-PRO.117	*Plugging and Abandonment of Boreholes*
RMRS/OPS-PRO.118	*Monitoring Wells and Piezometer Installation*
RMRS/OPS-PRO.102	*Borehole Clearing*
RMRS/OPS-PRO.123	*Land Surveying*
RMRS/OPS-PRO.124	*Push Subsurface Soil Sampling*
RMRS/OPS-PRO.105	*Water Level Measurements in Wells and Piezometers*
RMRS/OPS-PRO.106	*Well Development*
RMRS/OPS-PRO.108	*Measurement of Groundwater Field Parameters*
RMRS/OPS-PRO.113	*Groundwater Sampling*
RMRS/OPS-PRO.081	*Surface Water Sampling*
RMRS/OPS-PRO.094	*Field Measurements of Surface Water Field Parameters*
RMRS/OPS-PRO.115	*Monitoring and Containerizing Drilling Fluids and Cuttings*
RMRS/OPS-PRO.072	*Field Data Management*
ASD-003	*Identification System for Reports and Samples*

1.0 INTRODUCTION

1.1 Purpose

This Sampling and Analysis Plan (SAP) provides for monitoring well installation, groundwater sampling, and surface water sampling activities at the Property Utilization and Disposal (PU&D) Yard Plume project area at the Rocky Flats Environmental Technology Site (RFETS) as proposed under *Technical Memorandum, Monitored Natural Attenuation of the PU&D Yard VOC Plume* (RMRS, 1999a). A volatile organic compound (VOC) groundwater plume has migrated away from the source area at the PU&D Yard toward surface water streams. The SAP supports plume monitoring and characterization activities being conducted to evaluate monitored natural attenuation as an effective means of ensuring the protection of surface water quality.

The objective of this SAP is to define specific data needs, sampling and analysis requirements, data handling procedures, and associated Quality Assurance/Quality Control (QA/QC) requirements for field activities planned under this project. All work will be performed in accordance with the Kaiser-Hill (KH) Team, Quality Assurance Program (QAP) (KH, 1999). Field activities planned under this work plan are limited to well installation, well development, and groundwater and surface water sampling activities. The Groundwater Monitoring Program as specified in the Integrated Monitoring Plan (IMP) will accomplish additional groundwater sampling for longer-term monitoring.

This SAP incorporates information and data interpretations from previous investigations conducted at the project area as a basis for designing and implementing the proposed field activity. The purpose of the project is to confirm previous data, install new wells to accomplish this and fill data gaps, and to monitor for the occurrence of natural attenuation of the PU&D Yard VOC plume.

Implementation of this project will be performed in accordance with applicable Federal, State, and local regulations, as well as United States Department of Energy (DOE) Orders, RFETS policies and procedures, and Rocky Mountain Remediation Services, L.L.C. (RMRS) Operating Procedures.

1.2 Background

1.2.1 Site Description

Volatile organic compound groundwater contamination has historically been detected at the upgradient periphery of the Present Sanitary Landfill. The presence of VOC contamination in upgradient landfill wells, combined with historical documentation, land usage, and hydrogeologic considerations, point to the PU&D Yard, also known as Individual Hazardous Substance Site (IHSS) 170, as being the most likely source of groundwater contamination in this area (RMRS, 1999a). IHSS 170 includes IHSSs 174A and 174B, described below.

Figure 1-1 illustrates the location of the PU&D Yard and associated VOC plume with relationship to the Present Sanitary Landfill and Industrial Area (IA). The plume extends from the PU&D Yard on the west to above the landfill pond on the east resulting an overall length of about 2,600 feet and maximum width of about 570 feet. Plume occurrence is restricted mainly to a narrow upland ridge that separates the North Walnut Creek and No Name Gulch drainages. The north boundary of the plume is bounded by the Present Sanitary Landfill and is southwest of the Landfill Pond, which occupies the headcut of the former

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No Name Gulch drainage. The known plume extent is defined by numerous existing and abandoned monitoring wells that have been monitored at various frequencies since 1987.

The PU&D Yard IHSSs are located northwest of the IA in the Buffer Zone and were former storage areas for empty drums, cargo boxes, and dumpsters from 1974 to 1994 that contained unknown residual quantities and types of solvents and waste materials. Two areas within IHSS 170, IHSSs 174A and 174B, were designated for the storage of hazardous materials, specifically empty drums at IHSS 174A and a dumpster for the storage of stainless steel sheet metal chips and lathe turnings coated with freon-based or oil-based lathe coolant at IHSS 174B. Potential VOC contamination is probably due to leaking drums containing oil-solvents or metal turnings coated with oil-solvents at the surface, or as surface spills.

1.2.2 Previous Investigations

Previous information on IHSSs 170, 174A, and 174B is documented in an internal letter (Rockwell, 1987), the Closure Plan for the Container Storage Area (Rockwell, 1988), the Operable Unit (OU) 10 Phase I Resource Conservation and Recovery Act (RCRA) Field Investigation/Remedial Investigation (RFI/RI) Work Plan (DOE 1992a), Draft Technical Memorandum No. 1 - Data Summary for OU 10 (EG&G, 1995a), the Final Historical Release Report (HRR) (DOE, 1992b), Annual HRR Update Report (RMRS, 1999b), the Geologic and Hydrogeologic Characterization Reports for RFETS (EG&G, 1995b and 1995c), 1997 Annual RFCA Groundwater Monitoring Report (RMRS, 1998), and the Data Summary Report for IHSSs 170, 174A, and 174B, Property Utilization and Disposal Yard (RMRS, 1997a).

A soil gas survey performed per the Phase I RFI/RI consisted of 235 soil gas sample locations, some of which indicated the presence of volatile organic contaminants in subsurface soil. The primary VOCs detected were acetone, benzene, trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,1-trichloroethane (TCA). Soil gas survey anomalies indicative of subsurface contamination were identified in three areas: 1) the east-southeast side of IHSS 170; 2) the northeast corner of IHSS 170 and the north side of IHSS 174A; and 3) the oil stain area in IHSS 174B.

A total of 71 surface soil locations were sampled for the RFI/RI Work Plan (DOE, 1992a). Thirty-seven soil samples from IHSS 170, 26 soil samples from IHSS 174A, and eight soil samples from IHSS 174B were analyzed for total metals, semivolatile organic compounds, pesticides, and polychlorinated biphenyls (PCBs). Aroclor-1254 was observed in four samples from IHSS 174A at concentrations greater than the Rocky Flats Cleanup Agreement (RFCA) (DOE, 1996a) Tier II but less than the Tier I surface soil action levels (EG&G, 1995a). Beryllium was observed in two samples from IHSS 174A at concentrations greater than the RFCA Tier II but less than the Tier I surface soil action levels (EG&G, 1995a). Vanadium was observed in one sample from IHSS 174A at a concentration of 43,400 mg/Kg. This concentration is greater than the RFCA Tier I surface soil action level for industrial use but less than the RFCA Tier I surface soil action level for open space use.

High Purity Germanium and Sodium Iodide surveys of IHSSs 170, 174A, and 174B were also performed as part of the RFI/RI (EG&G, 1995a) with no anomalous results observed. However, according to an internal letter (Rockwell, 1987), a small spill of approximately 100 grams of green powder was reported from a drum in December 1987. The powder contained approximately 60 percent aluminum oxide, 32.5 percent chromium oxide, 3,000 pCi/g plutonium, 1,000 pCi/g americium, and 100 pCi/g uranium-235. The source of the powder was a result of using two drums of trichlorotrifluoroethane to clean some lines associated with the replacement of sintered metal filters on the fluidized bed incinerator. The liquid was subsequently discharged into storage tanks at Building 774 and the drum(s) were dispositioned at the PU&D Yard. This incident is most likely associated with IHSS 174A.

In 1997, a pre-remedial investigation of IHSSs 170, 174A, and 174B was conducted to evaluate if a source for VOCs in subsurface soils was present at the PU&D Yard that could be impacting groundwater and thus require remedial action (RMRS, 1997a). A total of twenty soil borings were advanced at the three IHSSs resulting in the collection of thirty-eight subsurface soil samples and six groundwater samples. VOCs were not detected above Tier I action level concentrations in any of the soil samples. A localized area of below the current Tier I action level for PCE contamination (BH17497) was identified as contributing to groundwater contamination greater than the Tier I action level. The report concluded that the PU&D Yard IHSSs did not require remediation for VOC soil contamination. Table 1-1 presents the results of the soil samples collected during the pre-remedial investigation.

A more extensive investigation of the PU&D Yard VOC plume was conducted as part of the Groundwater Evaluation Program (RMRS, 1998). Twelve new monitoring wells were installed within and around the perimeter of the PU&D Yard and downgradient areas, as shown in Figure 1-1. In addition, a line of fourteen wells was installed along the Northwest Access road to locate potential southern plume pathways to North Walnut Creek (Figure 1-1). Details of these well installations are provided in RMRS (1998). In 1998, a follow-up investigation into the function of the groundwater intercept and diversion system and its possible role in collecting and discharging PU&D Yard plume contaminants downgradient of the landfill was undertaken. This investigation consisted of a records search, field observation of drain valving and flow, and interpretation of analytical results of samples collected at the drain outfalls in 1998 and 1999. The analytical results from these outfalls is presented in the 1998 RFCA Annual Groundwater Monitoring Report (RMRS, 1998).

Table 1-2 presents the results of VOC groundwater sampling conducted at the PU&D Yard and surrounding area during the third and fourth quarters of 1997. For wells 01097 through 02197, detections of VOC compounds were found in all wells containing groundwater, including Tier II groundwater action level exceedances for TCE in wells 01497 and 02097; PCE in wells 01297 and 01397; and 1,1-dichloroethene (DCE) in wells 01497 and 01897. TCE, PCE, 1,1-DCE and 1,1,1-TCA were the most commonly detected compounds. The remaining compounds (carbon tetrachloride, chloroform, napthalene, 1,2-DCE, toluene, and 1,2,4-trimethylbenzene) were reported mainly at below detection levels. Wells 01797 and 02197 were dry at the time of sampling. VOCs do not occur in significant quantities in wells 21197 through 22497, thus indicating the absence of any significant PU&D Yard VOC plume movement towards North Walnut Creek. The B qualifier associated with the toluene results suggests that laboratory contamination is the probable cause for the positive detections in these samples.

Table 1-1
Summary of Soil VOC Analytical Results

Borehole No.	Sample Depth	Sample No.	PCE	TCE	Methylene Chloride	Napthalene
			11,500[a]	9,270[a]	5,770[a]	5,770,000[a]
17097	5.0-5.5	BH17000RM	ND<625	ND<625	620J	ND<625
	10.0-10.5	BH17001RM	ND<625	ND<625	664	ND<630
17197	5.5-6.0	BH17003RM	ND<625	ND<625	685	ND<630
	10.25-10.5	BH17004RM	ND<625	ND<625	689	ND<630
17297	5.0-5.5	BH17007RM	ND<630	ND<630	1600B	ND<630
	10.5-11.0	BH17008RM	ND<630	ND<630	1400B	ND<630
17397	5.0-5.5	BH17009RM	ND<630	ND<630	1300B	ND<630
	10.5-11.0	BH17010RM	ND<630	ND<630	1500B	ND<630
17497	4.3-4.9	BH17012RM	750	ND<630	ND<630	ND<630
	8.5-9.0	BH17013RM	830	ND<630	ND<630	ND<630
	11.0-11.5	BH17014RM	5700	ND<630	ND<630	ND<630
17597	4.7-5.3	BH17015RM	ND<630	ND<630	ND<630	ND<630
	11.0-11.5	BH17016RM	ND<630	ND<630	ND<630	ND<630
	10.5-11.0	BH17005RM	ND<630	ND<630	330JB	ND<630
17697	5.5-6.0	BH17018RM	ND<630	ND<630	530JB	ND<630
	9.8-10.3	BH17019RM	ND<630	ND<630	610JB	ND<630
17797	4.4-4.9	BH17020RM	ND<630	ND<630	2100JB	ND<630
17897	5.4-5.9	BH17023RM	ND<630	ND<630	ND<630	390J
17997	5.0-5.5	BH17024RM	ND<630	ND<630	ND<630	ND<630
	9.5-10.0	BH17025RM	ND<630	ND<630	ND<630	ND<630
	15.0-15.5	BH17026RM	ND<630	ND<630	ND<630	ND<630
	19.5-20.0	BH17027RM	ND<630	ND<630	ND<630	ND<630
18097	5.0-5.5	BH17028RM	ND<630	ND<630	440JB	ND<630
	4.5-5.0	BH17029RM	ND<630	ND<630	420JB	ND<630
18197	5.0-5.5	BH17030RM	ND<630	ND<630	2600JB	ND<630
18297	5.0-5.5	BH17032RM	ND<630	ND<630	400JB	ND<630
18397	5.0-5.5	BH17033RM	ND<630	ND<630	400JB	ND<630
18497	5.0-5.5	BH17034RM	ND<630	ND<630	410JB	ND<630
18597	5.0-5.5	BH17037RM	ND<630	ND<630	370JB	ND<630
18697	5.0-5.5	BH17038RM	ND<630	ND<630	400JB	ND<630
18797	4.5-5.0	BH17041RM	ND<630	ND<630	9.2JB	ND<630
	10.5-11.0	BH17042RM	ND<630	ND<630	6.6JB	ND<630
	14.0-14.5	BH17040RM	ND<630	ND<630	8.7JB	ND<630
	20.5-21.5	BH17043RM	ND<630	ND<630	9.1JB	ND<630
18897	4.5-5.0	BH17044RM	ND<630	ND<630	9.3JB	ND<630
	11.0-11.5	BH17045RM	ND<630	ND<630	9JB	ND<630
	15.0-15.5	BH17046RM	ND<630	ND<630	5.8JB	ND<630
	20.5-21.5	BH17047RM	ND<630	ND<630	5.6JB	ND<630
18997	5.0-5.5	BH117049RM	ND<630	360J	430JB	ND<630
	9.5-10.0	BH117050RM	ND<630	ND<630	3000B	ND<630

Note: [a]=RFCA Tier I subsurface soil action level (DOE, 1996a); * = duplicate sample; sample units are in µg/Kg; J estimated concentration of analyte detected below method practical quantitation limit; and B analyte appears in method blank.

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Table 1-2 Detected Volatile Organic Compounds in Groundwater (ug/L)

PU&D Yard Monitoring Wells

WELL	Sample Date	TCE		PCE		Carbon Tetrachloride		Chloroform		Napthalene		cis-1,2 DCE		1,1 DCE		1,1 DCA		1,1,1 TCA		Toluene		1,2,4 Trimethyl-benzene	
Groundwater Action Levels (K-H, 1997)		5		5		5		100		1460		70		7		1010		200		1000		70	
01097	9/25/97	1	U	2		1	U	1	U	1	U	1	U	1	U	1	U	1	U	0.4	J	0.3	J
01197	9/29/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
01297	9/25/97	1	U	**7**		1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
01397	9/30/97	0.2	J	**5**		0.2	J	1	U	0.4	JB	1	U	1		1	U	5		1	U	1	U
01497	9/25/97	**30**		4	J	**5**	J	6	U	6	U	6	U	**80**		3	J	170		6	U	6	U
01597	9/26/97	1	U	2		1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
01697	9/30/97	4		0.5	J	1	U	1	U	1	U	1	U	2		1	U	4		1	U	1	U
01797	Dry - sample not collected																						
01897	9/29/97	4		0.6	J	0.8	J	0.3	J	1	U	1	U	**7**		1	U	20		1	U	1	U
01997	9/30/97	2		4		1	U	1	U	1	U	1	U	2		1	U	6		1	U	1	U
02097	9/30/97	**10**		2		1	U	0.4	J	1	U	0.8	J	2		3		7		1	U	1	U
02197	Dry - sample not collected																						
21197	8/14/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
21297	8/14/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
21397	11/12/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
21497	11/12/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	0.2	JB	1	U
21597	11/12/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	0.2	JB	1	U
21697	11/12/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	0.3	JB	1	U
21797	11/12/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
21897	Dry - sample not collected																						
21997	11/12/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
22097	11/11/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
22197	11/11/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
22297	11/10/97	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
22397	Insufficient water for sample																						
22497	Insufficient water for sample																						

Note: U = Analyzed chemical was not detected
J = Estimated result – chemical detected below CRDL
B = Chemical also found in method blank
Bold, Shaded values equal or exceed Groundwater action Level

Figure 1-2 illustrates the layout of the groundwater intercept and diversion system. Information presented in the *Phase I RFI/RI Work Plan for Operable Unit No. 7 - Present Sanitary Landfill* (DOE, 1991) and other Operable Unit 7 documentation contain engineering design specifications and a hydrologic analysis of system effectiveness. However, these documents contain little information on system operation, such as present-day valve configurations and discharge data, which disclose the fate of groundwater intercepted by the system.

Discharge at drain outfalls SW099 and SW100 located below the landfill pond dam is usually minimal or absent. Observation of drain outfalls SW099 and SW100, located on Figure 1-2, was conducted at roughly monthly intervals during the fall and winter of 1998, and spring of 1999. In December 1998, a sufficient amount of flow was observed at SW099 (0.007 gallons per minute [gpm] on 12/18/98) to justify sampling for VOCs. The SW100 outfall was dry during all site visits prior to April 1999, except for incident precipitation, which had built up inside the weir box. On April 29, 1999, flows from both outfalls were observed and a complete sample set was collected for VOCs, metals, radionuclides (Pu-239/240, Am-241, uranium 233/234, uranium 235, uranium-238, and tritium), and water quality parameters (total dissolved solids, sulfate, fluoride, and nitrate/nitrite). Discharges of 0.5 gpm at SW099 and 1.3 gpm at SW100 were measured prior to sampling. VOCs characteristic of PU&D Yard groundwater contamination were not detected in samples collected at either outfall.

1.3 Hydrogeologic Setting

The information contained in the following sections was derived from the investigations described above, recent plume boundary interpretations (RMRS, 1998), historical groundwater data, and field observations.

1.3.1 Geology

RFETS is situated at the margin of a gently eastward sloping topographic and bedrock pediment surface mantled by unconsolidated Pleistocene Rocky Flats Alluvium and underlain mainly by claystones, siltstones, and sandstones of the Cretaceous Arapahoe and Laramie Formations (EG&G, 1995b). East of this margin, colluvium-covered hillslopes dominate the landscape, except along valley bottoms where valley-fill alluvial deposits occupy the major stream courses. The PU&D Yard source areas are situated on the Rocky Flats Alluvium, although the groundwater VOC plumes associated with these sources involve all three types of surficial geological deposits, and to a lesser extent, weathered bedrock.

The Rocky Flats Alluvium is comprised chiefly of poorly sorted, clayey gravels and sands with abundant cobble and boulder-sized material and discontinuous lenses of clay, silt, and sand. At the PU&D Yard, the thickness of this deposit ranges from approximately 10 to 40 feet. Hillside colluvial deposits are markedly finer-grained in texture, being comprised of clay, clayey gravels, and lesser amounts of sand and silt. These deposits were derived from geologic material exposed on the steep slopes and topographic highs, and were formed by slope wash, downslope creep, and landslide action. Valley-fill deposits were fluvially derived from upstream materials, and consist of clay, silt, and sand with lenses of gravel. These valley-fill deposits occur along the drainage bottoms in and adjacent to streambeds, and are most common in the eastern portions of RFETS.

The Arapahoe Formation is 0 to 50 feet thick at RFETS and consists mainly of a discontinuous, but mappable, fine- to medium-grained, moderately- to poorly- sorted sandstone unit that forms the uppermost sandstone of significant lateral extent. This sandstone unit is referred to as the Arapahoe Formation (or No. 1) sandstone (EG&G, 1995b) and is known to locally subcrop beneath the Rocky Flats Alluvium and colluvium in portions of the eastern Industrial Area (IA). It has been shown to be an important pathway for the lateral transport of contaminated groundwater to hillslopes in certain areas of RFETS, particularly South Walnut Creek east of the IA.

The Laramie Formation conformably underlies the Arapahoe Formation and consists primarily of massive claystone and siltstone with discontinuous clayey sandstone units (EG&G, 1995b). Unlike the Arapahoe Formation sandstone, these sandstone units exhibit lithologic and hydrologic characteristics (i.e., high matrix clay content and low permeability) that are not indicative of contaminant pathways. These lenticular Laramie Formation sandstones are texturally distinct from the Arapahoe Formation sandstone by virtue of their high silt and clay content (EG&G, 1995b).

1.3.2 Groundwater Occurrence and Distribution

All unconsolidated surficial and consolidated bedrock geologic deposits contain groundwater although groundwater conditions are known to vary widely across the Site as a function of topography, geologic unit, location, and season. Shallow groundwater flow is generally confined to the upper hydrostratigraphic unit (UHSU), which consists of Rocky Flats Alluvium, colluvium, valley-fill alluvium, and weathered bedrock materials, and locally lenses of the Arapahoe Formation sandstone. Consequently, most RFETS groundwater plumes are limited to the UHSU. Groundwater in the underlying lower hydrostratigraphic unit (LHSU) occurs in low permeability unweathered bedrock materials that are hydrologically poorly connected with the UHSU. The LHSU at RFETS is essentially uncontaminated.

The PU&D Yard VOC plume is confined to the UHSU. The local hydrogeologic setting controls groundwater occurrence in the UHSU deposits. In the PU&D Yard area, the main sources of UHSU groundwater include infiltration of incident precipitation and seasonal leakage from diversion ditches located just to the north, especially during the spring months. Depth to groundwater is approximately 5 to 20 feet with a hydraulic gradient of approximately 0.02 ft/ft towards the east (RMRS, 1999a).

As shown on Figure 1-3, alluvial groundwater flows generally eastward across the pediment surface until it is intercepted by the Present Sanitary Landfill groundwater intercept and diversion system/No Name Gulch watershed to the northeast, or the North Walnut Creek watershed to the south and southeast. Groundwater is discharged from the Rocky Flats Alluvium to the colluvium at seeps found near the pediment rim which, in turn, discharge to the valley fill alluvium associated with North Walnut Creek and No Name Gulch. Alluvial groundwater also enters into the groundwater intercept system at the landfill perimeter and is discharged as surface water below the landfill pond dam into No Name Gulch (SW099 and SW100). In addition, it is possible that a small fraction of groundwater flow circumvents the groundwater intercept and diversion system, enters landfill refuse material, and is ultimately discharged from the toe of the landfill at SW097. The distribution of contaminant concentrations within the PU&D Yard VOC plume indicates the principal groundwater flow pathway from the PU&D Yard is towards No Name Gulch.

Based on CDPHE comments regarding the *Technical Memorandum, Monitored Natural Attenuation of the PU&D Yard VOC Plume* (RMRS, 1999a), our interpretation of groundwater flow and PU&D Yard

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plume movement into the Present Landfill, rather than out of the Present Landfill is based on the following conditions:

- Water level elevations at wells 7287 and B206489 (south of the slurry wall) are approximately 4 feet higher than at well B206389 (north of the slurry wall), indicating a hydraulic gradient across the slurry wall toward the landfill.

- Concentration gradients of selected inorganic contaminants such as chloride, bicarbonate, iron, manganese, and total dissolved solids, presented in the *Groundwater Geochemistry Report for RFETS* (EG&G, 1995d), indicate the type of pattern that would be expected for a groundwater flow direction toward the center of the landfill. As groundwater travels through refuse, the concentration of these contaminants would be expected to increase along the flow path. For groundwater to flow south and out of the landfill, one would expect to see an opposite pattern; concentrations should be higher at the south margin than at the landfill center.

- Parameters indicative of landfill leachate, such as elevated iron, manganese, total organic carbon, and total dissolved solids (TDS), which are found at well B206389, are not detected in significant concentrations at wells 7287 and B206489.

1.3.3 Type and Extent of Contamination

Based on CDPHE comments regarding the *Technical Memorandum, Monitored Natural Attenuation of the PU&D Yard VOC Plume* (RMRS, 1999a), the analytes of concern have been plotted and contoured on an individual basis on Figures 1-4 through 1-10. These analytes together comprise the composite VOC plume, which is found in the UHSU. By looking at the analytes individually, we may more accurately locate the source area(s) and plot all potential groundwater and contaminant pathways. The individual analyte plots will help to delineate more accurate contaminant pathways than the composite PU&D Yard VOC plume map.

Technically, the VOC plume depicted in Figure 1-1 is a composite representation of TCE, PCE, 1,2-DCE, and vinyl chloride groundwater concentrations that exceed the Tier I and Tier II action level criteria. The distribution of individual PU&D Yard contaminants of concern (Figures 1-4 through 1-10) is more complex than depicted by the composite plume map. The composite plume boundaries were drawn based on a comparison of VOC compounds found within and outside of the landfill. The data suggest that the chlorinated organic compounds observed in the PU&D Yard plume are prevalent in wells located south of the groundwater intercept system, while organic compounds found within the boundaries of the intercept system show more variable organic affinities (DOE, 1995, 1996b). Of special note is the presence of 1,1,1-TCA (Figure 1-10), which is a good indicator compound for PU&D Yard contamination. This compound is detected in wells south of the intercept system but not in wells within the intercept boundaries. The potential incursion of PU&D Yard plume contaminants into the landfill and the apparent extent of the PU&D Yard plume beyond the east face of the landfill indicates a potential future impact to the No Name Gulch drainage. As described previously in Section 1.2.2, sample results from drain discharges indicate that surface water quality in No Name Gulch is currently not being impacted by PU&D Yard plume contaminants.

Concentrations of TCE (20 to 30 μg/L), 1,1-DCE (10 to 80 μg/L), and 1,1,1-TCA (30 to 170 μg/L) in wells 70393 and 01497, and PCE in wells 01397 (5 μg/L), 01297 (7 μg/L), and borehole 17497 (1,700 μg/L), indicates the type of VOC contamination that is associated with the PU&D Yard, most probably

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IHSS 174A. From the PU&D Yard, groundwater is observed to migrate longitudinally eastward along the south boundary of the landfill and laterally to the south, where alluvial groundwater discharges to the North Walnut Creek drainage as hillside seeps (i.e., well 61495) and shallow subsurface flow. Considering the fact that groundwater once discharged to the No Name Gulch valley headcut (indicated by seepage areas present in a 1937 aerial photograph), now filled with landfill refuse, the shape and orientation of the plume strongly suggests that plume migration is at least partially influenced by interaction with groundwater control structures (groundwater-intercept and slurry wall system) and diverted around the south perimeter of the landfill.

Near the northeastern end of the composite plume, a second potential source area is suggested from VOC signatures and concentrations at wells 7287 and B206489 (both abandoned). The highest concentrations of TCE, PCE, and carbon tetrachloride in the PU&D Yard Plume previously occurred in well 7287. Well B206489, previously located next to 7287, also contained relatively high concentrations of TCE and 1,2-DCE. These wells were located near well B206389 (abandoned), which previously contained the highest concentrations of these analytes in the vicinity of the PU&D Yard. Well B206389 was located north of the groundwater intercept and diversion system and was designed to monitor groundwater within the landfill rather than the PU&D Yard. The source of these contaminants is unknown, but is probably located somewhere in the eastern one third of the plume near the contaminated wells and east of wells 6587 (abandoned), 6687 (abandoned), and 00597. Because multiple sources may contribute to composite plume shape and extent, these parameters cannot be used to provide reliable indicators of plume migration rate away from the PU&D Yard area.

Re-examination of VOC data for wells 6474, 6574 (both abandoned), and 77392 resulted in the elimination of the easternmost plume lobe shown previously in RMRS (1998). This lobe was originally drawn to incorporate previous single detections of vinyl chloride above Tier II action levels (2 μg/L) in wells 6474 and 6574. The repeated absence of vinyl chloride in well 77392, combined with the absence of vinyl chloride in all other wells at the PU&D Yard, indicate that the previous vinyl chloride detections in wells 6474 and 6574 were probably spurious values which are not representative of actual groundwater quality.

1.3.4 Conceptual Model

Based on the existing data and hydrogeologic setting, a conceptual model of plume migration has been developed for the investigation area. Contaminants present in the groundwater exist as a result of historical releases from equipment and drum storage operations at the PU&D Yard. Drums containing VOCs leaked into the soil, and were flushed into groundwater where the compounds dissolved and were slowly transported laterally away from source areas along prevailing groundwater flow paths. Dense non-aqueous phase liquids (DNAPLs) have not been found to date at the PU&D Yard VOC plume investigation area.

As discussed in Section 1.3.3, and based on a review of Figures 1-4, 1-5, and 1-6, it appears that there may be an additional groundwater source located in the northeast portion of the composite plume. High concentrations of PCE, TCE, and 1,2-DCE have been observed there. It is not known at this time if this contamination is associated with the PU&D Yard, but for the purpose of this SAP it is being treated as part of the PU&D Yard composite plume.

VOC-contaminated groundwater originating at the PU&D Yard area initially flows to the east and subsequently spreads to the northeast towards No Name Gulch, and to the southeast towards North

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Walnut Creek (Figure 1-3). Alluvial groundwater flow discharges to hillside colluvial and weathered bedrock material to the south of the plume at isolated small seeps. The PU&D Yard VOC plume does not appear to make it as far south as the seeps. The several small hillside seeps may indicate preferential flowpath locations related to plume migration routes.

With respect to this project, new investigation within the perimeter of the Present Landfill (i.e., drilling) is not necessary. Determinations of concentrations of VOCs in the Present Landfill that are associated with the PU&D Yard Plume will depend on historic data. Based on the trend of the PU&D Yard composite VOC plume, routes to surface water will be investigated through avenues other than the Present Landfill. Determination of what is emanating at the downstream end of the Landfill Pond will be implemented through analysis of water from Surface Water stations SW099 and SW100.

The following conclusions were made in the *Technical Memorandum, Monitored Natural Attenuation of the PU&D Yard VOC Plume* (RMRS, 1999a) based on existing data:

- Monitoring of contaminant concentrations in selected wells and drain outfalls located at and beyond the leading edge of the plume needs to be performed to verify that natural attenuation processes are capable of controlling contaminant concentrations and fluxes to levels that are protective of surface water.

- The presence of degradation products of the three contaminants of concern (PCE, TCE, and carbon tetrachloride) suggests that small quantities from the original release might be biodegraded. Because of processes normally associated with landfills (i.e., dissolved methane production, anaerobic conditions), biodegradation may be enhanced within the Present Landfill.

- Hydrogeologic factors, such as advection, dispersion, sorption, and volatilization may have an impact on contaminant migration. However, these processes are not attenuating plume migration near the PU&D Yard source as demonstrated by the wide extent of plume contamination.

- Depletion of residual contaminant source material may be occurring as evidenced by declining concentration trends observed in some monitoring wells. The prevalence of low VOC concentrations detected in PU&D Yard monitoring wells provide evidence of low source area concentrations indicative of a relatively small and diffuse contaminant mass.

- There is no evidence that the PU&D Yard Plume is currently impacting surface water quality.

2.0 SAMPLING RATIONALE

Historical information detailed in Section 1.2 was used to develop a systematic sampling strategy for this investigation. The sampling rationale also accounts for the potential presence of preferential groundwater flow paths discussed in Section 1.3.2 and shown on Figure 1-3. New monitoring well locations and existing wells to be sampled in support of this SAP have been selected along the groundwater flow path(s) delineated by previous investigations. Groundwater sampling will be implemented in new and existing monitoring wells during an initial sampling round that will serve to delineate the pathway(s) for the PU&D Yard composite VOC plume. This sampling round may consist of as many as 19 existing downgradient wells, 10 existing in-plume wells, 7 existing cross gradient or upgradient wells, 7 new downgradient monitoring wells, and one new well upgradient of the potential groundwater source (located in the northwest portion of the composite VOC plume) identified in Sections 1.3.3 and 1.3.4. In addition,

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samples will be collected from two surface water stations immediately below the Landfill Pond and at least one seep to further define the extent of plume contamination. Should some combination of new and existing downgradient monitoring wells detect VOC contamination above MCLs, then the assumption will be made that there is a pathway to surface water which, potentially, is contaminated with VOCs.

A second sampling round, to determine if natural attenuation is occurring, will consist of 4 monitoring wells within the footprint of the PU&D Yard composite VOC plume. These four wells will be identified based on the results of the initial sampling round. The pathway between groundwater and surface water identified by the initial sampling round will dictate the linear orientation of the four wells. In general, one well will be near the source area, one near the distal end of the pathway, and two wells will be located along the pathway. This approach will ensure that the extent and orientation of the composite VOC plume is understood before natural attenuation monitoring is implemented. The following conditions were considered in the development of the sampling strategy:

- The operating history of the PU&D Yard indicates that VOCs have been released to the groundwater environment and have migrated toward surface water streams;

- The physical and chemical properties of the contaminants and available groundwater data indicate that natural attenuation processes may have potentially reduced plume contaminant concentrations downgradient of source areas, and may have been effective at mitigating plume advancement;

- Hillslope groundwater contaminant occurrence is limited, difficult to predict, and may be confined to preferential flow pathways found within colluvial and valley-fill materials associated with stream valleys;

- Contaminant concentrations at wells are influenced by plume dynamics and seasonal factors, such as water table fluctuations, and;

- Preferential groundwater flow pathways may cause significant local effects on groundwater flow direction and discharge, including seep occurrence, that can affect monitoring system design and project success.

3.0 DATA QUALITY OBJECTIVES (DQOs)

The data quality objective process consists of seven steps and is designed to be iterative; the outputs of one step may influence prior steps and cause them to be refined. Each of the seven steps is described below for the investigative area shown in Figure 4-1. Data requirements to support this project were developed and are implemented in the project using criteria established in *Guidance for the Data Quality Objective Process*, QA/G-4 (EPA, 1994).

3.1 State the Problem

Previous investigations of the Site have identified VOC contaminated groundwater associated with solvent releases from the PU&D Yard. This plume, or potentially plumes, has migrated away from source areas toward surface water streams. The investigation outlined in this SAP, utilizing existing wells and positioning new wells to be used for mapping plume extent, will better delineate the PU&D Yard composite VOC plume and the groundwater flow pathway(s) associated with VOC contamination. Natural attenuation monitoring, as proposed in the *Technical Memorandum Monitored Natural*

Attenuation of the PU&D Yard VOC Plume (RMRS, 1999a), will also be addressed. Groundwater monitoring will be initiated to determine plume extent and assess the adequacy of natural attenuation processes for limiting risk to surface water quality from VOCs. This approach will be supplemented by surface water sampling designed to validate the assumption that there is no current impact of plume VOC contaminants on surface water quality.

3.2 Identify the Decision

Decisions required to be made using field data (including water levels and samples for analytical laboratory analyses) collected from monitoring wells, seeps, and surface water stations include:

- Do favorable groundwater conditions (i.e., saturated geologic materials) exist downgradient of the PU&D Yard VOC plume for the installation of short-term monitoring wells that will be used to monitor plume location and/or natural attenuation in the plume?

- Do contaminant trends in newly installed wells indicate that natural attenuation is an effective mechanism for protecting surface water quality?

- Is the PU&D Yard VOC plume currently impacting surface water quality?

3.3 Identify Inputs to the Decision

Inputs to the decision include field observations and measurements of groundwater occurrence and distribution, and VOC analytical results for groundwater samples collected from selected monitoring wells, surface water stations, and seeps for determination of the PU&D Yard Plume extent and concentration. Surface water VOC samples will be used to assess impacts of the PU&D Yard Plume on surface water quality. The parameters of interest include:

- Depth to bedrock below ground level for new and existing wells (for calculating saturated thickness)
- Depth to water below ground level for new and existing wells (for calculating saturated thickness)
- Saturated thickness
- Initial water level recovery rate
- Groundwater VOC concentrations
- Surface water VOC concentrations
- Surface water discharge, including flow rates

Volatile organic chemical results of groundwater samples collected from existing and new monitoring wells for comparison to RFCA Action Levels (DOE, 1999), and potentially for trend analysis, are inputs necessary for making decisions related to plume fate and risk to surface water quality. The parameters of interest, sample quantities, and analytical methodology are provided in Table 4-2.

Streamflow measurements at each surface water sampling location will provide additional data for interpreting surface water VOC analytical results. Land surveying of new well casing locations (± 0.1 foot) and elevations (± 0.01 foot) will be conducted to provide control for potentiometric contouring.

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3.4 Define the Boundaries

The investigative boundaries and rationale are detailed in Section 4.0 of this SAP.

3.5 Develop a Decision Rule

The decision rule for installing new monitoring wells is based on the presence and amount of free groundwater found at drilling sites and the locations of the wells with respect to the presently known VOC plume configuration. The new monitoring well locations are based on results of previous hydrogeologic investigations, current-day field observations, interpretation of groundwater flow directions, and seep locations. Dry monitoring wells, while providing locations that are unsuitable for groundwater sampling, do provide important short and long-term data with regard to localized saturation conditions within the UHSU and locally within the PU&D Yard contaminant plume. Borings with the greatest saturated thickness and quickest recovery rates are considered more likely to be preferential pathways for contaminant transport.

Surface water sampling locations have been chosen where plume flowpaths are projected to intersect No Name Gulch and North Walnut Creek. These locations will be sampled initially to quantify potential contaminant load to surface water.

The decision rule on further investigation or remediation will be based on 1) an analysis of sampling results using contaminant trend and surface water loading calculations, and 2) seep and surface water sample results. Table 3-1 contains the Rocky Flats Environmental Technology Site Action Level Framework (ALF) surface water action levels for contaminants-of-concern that will be used for evaluating this decision.

Table 3-1
ALF Surface Water Action Levels for the PU&D Yard Plume Contaminants-of-Concern

Compound	ALF Action Levels for Surface Water (µg/L)
Carbon Tetrachloride	5
cis-1,2-Dichloroethene	70
Vinyl Chloride	2
Tetrachloroethene	5
1,1-Dicloroethene	7
1,1,1-Trichloroethane	200
Trichloroethene	5

Additional characterization, if required, will be based upon an evaluation of data collected under this SAP and performed through the groundwater evaluation process specified in the IMP. Groundwater monitoring will be performed in accordance with this SAP and incorporated into the next update of the IMP.

3.6 Specify Limits on Decision Errors

Confidence in contaminant monitoring for the PU&D Yard plume and subsequent project decisions is dependent on monitoring well siting, timing of groundwater and surface water sample collection, sampling results, sampling frequency, and quality control. Quality control of field measurements and

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laboratory analytical data collected during the investigation is important because decision errors may result if not based on reliable information.
Monitoring well placement will be accomplished through the use of a Geoprobe® boring program designed to locate groundwater flow pathways related to plume movement. New or existing monitoring wells used to delineate the PU&D Yard VOC plume will be no further than 200 feet apart. New monitoring well placement is based on a professional judgement approach utilizing previous investigation results, the interpretation of current site conditions described in Section 1.0, and real-time exploratory boring results.

Initially, sampling will consist of a sampling round involving many wells (identified in Section 4.1) that will serve to delineate the pathway(s) for the PU&D Yard VOC plume. A second sampling round, to determine if natural attenuation is occurring, will consist of four (4) monitoring wells within the PU&D Yard VOC plume. This approach will ensure that the extent and orientation of the VOC plume is understood before natural attenuation monitoring is performed. Future sampling of the PU&D Yard Plume will be performed as required under the IMP.

Quality control samples for the project will include a 1 in 20 frequency for duplicate samples and equipment rinsates for VOC analysis. Relative percent difference (RPD) goals for groundwater VOCs will be 30% or less. A completion goal of 90% of the data analyzed and verified will be of acceptable quality for decision making. Twenty-five percent of the total analytical data will undergo validation by a third party. The remaining 75 percent of the data will be verified.

Unless otherwise specified in this SAP, all fieldwork will be performed in accordance with approved RMRS standard operating procedures (SOPs). These procedures specify methods and equipment for ensuring the accuracy and integrity of well installations, field parameter measurements, sampling, and other related field data collection activities. A listing of applicable procedures is provided at the beginning of this document.

3.7 Optimize the Design for Obtaining Data

Monitoring well network design will be optimized through a combination of hydrogeologic interpretation of existing data and monitoring wells in addition to new monitoring wells. With this approach, potential plume pathway routes identified from previous investigation data and projected east, with subsequent northeast and southeast components, are investigated as potential contaminant pathways. Borings will be advanced into weathered bedrock, where there is less than five feet of alluvium and/or colluvium, in search of UHSU groundwater.

Surface water sampling design will be optimized by utilizing previous sampling results and existing locations to locate the likely discharge points for plume pathways in the No Name Gulch and North Walnut Creek. Groundwater will be sampled at seep location SW00495 (see Fig. 4-1) by inserting a temporary well immediately north of where the seep crops out of the hillside. Samples will be collected once to evaluate current impacts to surface water quality.

Subsequent sampling timing and frequency will be specified in the IMP based on the sampling results of the investigation as detailed in this SAP. For plume monitoring purposes, only VOC samples will be collected under this SAP, as the purpose of the monitoring program involves an evaluation of primary contaminant concentrations and trends for protecting surface water quality.

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4.0 SAMPLING ACTIVITIES AND METHODOLOGY

4.1 Sampling Station Locations and Numbering

4.1.1 Monitoring Wells

Eight (8) new monitoring well locations have been chosen to monitor groundwater quality associated with the PU&D Yard VOC plume. Seven wells (30100 through 30700) will be positioned to monitor downgradient groundwater quality at locations where there are current data gaps. Well 30800 will be positioned to monitor groundwater quality upgradient of the potential source area located in the northwest portion of the PU&D Yard composite plume. New wells 30100 through 30700 have been positioned with respect to existing wells so that there is no more than 200 feet between wells that will be used to determine the PU&D Yard Plume pathway. Figure 4-1 illustrates the approximate location of these wells in relationship to the probable plume pathway located from hydrogeologic considerations. The total number and arrangement of wells reflects the spatial limitations imposed by the terrain and expected geometry of the plume pathway. Well numbers (location codes) were assigned based on a five digit numbering system adopted by the Site in 1992, with the year drilled indicated by the last two digits. The rationale for each new monitoring well location is summarized in Table 4-1.

In addition to the new monitoring wells described above, existing, appropriately positioned and constructed monitoring wells will be utilized to monitor in-plume concentrations, cross gradient and upgradient locations, and downgradient locations. These existing wells, as well as the new wells described above, will all be sampled to provide a current picture of the extent and orientation of the PU&D Yard VOC plume.

The existing well locations to be used in support of this SAP are listed below:

In-Plume Locations		Cross and Upgradient Locations	
00597	02097	5887	21297
01297	70393	01097	21397
01397	70693	01197	
01497	61495	01597	
01897	01797	21197	

Downgradient Locations			
B206689	61695	21897	22497
77392	00397	21997	
308-P-1	21497	22097	
01997	21597	22197	
61595	21697	22297	
01697	21797	22397	

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Table 4-1
New Monitoring Well Location Rationale, PU&D Yard

Well Number	Location	Rationale
30100	Approximately 180 feet east of SW00495	To monitor downgradient water quality; fill data gap between SW00495 and well 30200
30200	Approximately 140 feet east/northeast of well 30100	To monitor downgradient water quality; fill data gap between wells 30100 and 30300
30300	Approximately 180 feet east of well 30200	To monitor downgradient water quality; fill data gap between wells 30200 and 308-P-1
30400	Approximately 170 feet north/northeast of well 308-P-1	To monitor downgradient water quality; fill data gap between wells 308-P-1 and 77392
30500	Approximately 200 feet north of well 77392	To monitor downgradient water quality; fill data gap between wells 77392 and B206689
30600	Approximately 140 feet northwest of well B206689	To monitor downgradient water quality; fill data gap between wells B206689 and 30700
30700	Approximately 160 feet northwest of well 30600	To monitor downgradient water quality; fill data gap past expected distal end of plume
30800	Approximately 100 feet west-southwest of the location of abandoned wells B206489 and 7287	To monitor groundwater quality upgradient of the potential source in the northwest portion of the PU&D Yard composite plume

Monitoring wells 21297, 21397, 21797, 21897, 22397, 22497, and 02097 have sustained some damage because of their proximity to roads. Most of these wells have bent or broken off pvc casing and can be repaired and utilized for sampling in support of this investigation. Should it be determined that a well is irreparable, the relative importance of its location (i.e., downgradient versus crossgradient) shall be determined and, if required, it will be replaced.

4.1.2 Surface Water Stations

Surface water sampling sites for the PU&D Yard plume (SW100 and SW099) are shown in Figure 1-2 and located immediately downstream of the Landfill Pond. Sample location SW00495 will consist of a temporary, hand hammered, drive point (1- or 2-in ID, approximately 5 feet deep, slotted along its length) that will be placed immediately upstream of where the seep crops out of the hillside. This will allow for the seep water to be collected before it daylights, thereby ensuring the integrity of VOC samples collected

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there. The approach of collecting surface water from a few key locations will better delineate potential groundwater flowpaths and discharge areas associated with plume migration, which in turn will aid in identifying stream reaches that are likely to receive the greatest contaminant fluxes.

4.2 Well Design and Installation

4.2.1 Well Design

Geoprobe® monitoring wells have been selected for monitoring the PU&D Yard VOC plume. Construction of these wells will be suitable for short-term monitoring of shallow water-bearing zones. These wells will be designed with screened intervals that fully penetrate saturated alluvium or colluvium and partially or fully penetrate weathered bedrock materials, as each location dictates, to detect lateral migration of contaminants in the UHSU. The screened interval for new wells will be selected to account for seasonal fluctuations in water table depth. Final depth determinations will be made in the field based on drilling conditions and initial depth to water.

At the proposed locations of new PU&D Yard VOC plume monitoring wells, the thickness of alluvial and/or colluvial deposits is between 0 and 12 feet. Evidence from existing wells generally indicates the presence of thinly saturated conditions. It is anticipated that new monitoring wells 30100 through 30700 will be between 10 and 20 feet deep, with a screened interval length of approximately 5 to 10 feet.

All wells will be installed using construction methods described in RMRS/OPS-PRO.118, *Monitoring Well and Piezometer Installation*. Radiological soil contamination is not anticipated at any of the drilling locations associated with this SAP. Should pre-drilling surveys indicate the need, a specialized surface casing configuration can be utilized (reference procedure RMRS/OPS-PRO.114). Typical well construction materials will consist of ¾ to 1-inch ID, schedule 40 or 80 polyvinyl chloride (PVC) riser and factory cut (0.010-inch slot width) well screen. Silica sand (16-40), granular bentonite or bentonite pellets and bentonite grout are used to complete the wells. If a truck mounted drill rig is required, wells will be constructed of 2-inch ID PVC riser and factory cut (0.010-inch slot width) screen. Protective casing consisting of 6-inch ID or larger steel riser with locking cap and lock will be set in sackrete to a depth of approximately 2 to 3 feet.

4.2.2 Pre-Drilling Activities

Before advancing boreholes, all locations will be cleared in accordance with RMRS/OPS-PRO.102, *Borehole Clearing*, and marked in accordance with RMRS/OPS-PRO.124, *Push Subsurface Soil Sampling*. A radiological survey will be conducted before site work begins in accordance with 5-21000-OPS-FO.16, *Field Radiological Measurements*. All Health and Safety protocols will be followed in accordance with the *PU&D Yard Plume Health and Safety Plan* addendum, as appropriate.

4.2.3 Borehole Drilling and Logging

Boreholes will be drilled at proposed well sites using push-type techniques (Geoprobe®). Detailed drilling and sampling procedures using this methodology are provided in OPS-PRO.124. If probe refusal is encountered before reaching bedrock, the borehole will be abandoned using procedure OPS-PRO.117, *Plugging and Abandonment of Boreholes*, and an offset boring will be attempted within 3 feet of the original boring. If probe refusal occurs, or the target depths are determined to be too great to penetrate with the Geoprobe®, a conventional truck-mounted drill rig utilizing hollow-stem augers will be procured to allow for the desired well completion(s). All hollow-stem auger drilling activities will comply with procedure OPS-PRO.114, *Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques.*

Soil cores will be recovered continuously in 1- to 4-foot increments using a 2.125-inch diameter by 48-inch long stainless steel- or lexon-lined California core barrel. Cores will be monitored following recovery for health and safety purposes with a Flame Ionization Detector (FID) or a Photoionization Detector (PID), as appropriate, in accordance with Site Procedure 5-21000-OPS-FO.15, *Photoionization Detectors and Flame Ionization Detectors.* The core samples will then be boxed and logged in accordance with OPS-PRO.101, *Logging Alluvial and Bedrock Material,* except that logging will be conducted more qualitatively than specified in OPS-PRO.101 (i.e., sieving, microscope examination, and plasticity testing will not be conducted). All core boxes will be labeled and transferred to a core storage conex for archiving following project completion.

After the boring reaches the desired depth in alluvium, colluvium, or weathered bedrock, an initial saturated thickness will be estimated from water level measurements made within the boring through the drive pipe or temporary retrievable casing. A water level measurement will be made after a 24-hour or longer period, which more likely represents actual water level equilibration.

4.2.4 Well Installation

Groundwater monitoring wells will be installed in accordance with RMRS/OPS-PRO.118, *Monitoring Wells and Piezometer Installation.* Monitoring wells will be land surveyed in accordance with OPS-PRO.123, *Land Surveying,* or current RFETS global positioning system manuals.

4.3 Well Development

Monitoring wells will be developed prior to sampling using the procedures specified in OPS-PRO.106, *Well Development,* with the exception that repeated vigorous surging utilizing a bailer may be employed to expedite formation damage restoration and maximize well yields for groundwater sampling. This approach has the best chance for success in wells containing a sufficient water column for surging and a thin annular sand pack, such as Geoprobe® wells. Under these conditions, the removal of fines associated with formation damage can be more effectively accomplished because a greater amount of surge energy is transmitted through the sand pack to dislodge materials at the borehole wall interface compared to wells completed with thick annular sand packs. All water produced during well development will be handled as uncharacterized development water in accordance with RMRS/OPS-PRO.128, *Handling of Purge and Development Water.*

4.4 Sample Designation

The site standard sample numbering system will be implemented in this project. Location codes have been assigned to new monitoring wells as shown in Figure 4-1 and listed in Table 4-1 using the Analytical Services Division (ASD) procedure ASD-003, *Identification System for Reports and Samples.* For each groundwater sample or surface water sample, dual sample numbers will be assigned: 1) a standard report identification number (RIN) (i.e., 00AXXXX.00X.00X) will be assigned to the project by the ASD, and 2) an RMRS sample number (i.e., GW0XXXXRG) for internal sample tracking. The block of sample numbers will be of sufficient size to include the entire number of possible samples (including

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QA samples) and location codes. For the final report, the ASD and RMRS sample numbers will be cross-referenced with location codes.

4.5 Sample Collection

4.5.1 Groundwater Samples

Prior to sample collection, the water level will be measured according to OPS-PRO.105, *Water Level Measurements in Wells and Piezometers*, to determine purge water requirements.

Groundwater samples will be collected using the methods specified in OPS-PRO.108, *Measurement of Groundwater Field Parameters*, and OPS-PRO.113, *Groundwater Sampling*. After an initial sampling round is completed for all new wells, sampling of wells will be conducted as specified by the IMP (to be modified for PU&D Yard plume monitoring wells).

4.5.2 Surface Water Samples

Very small flows are anticipated at surface water stations SW099, SW100, and seep SW00495. Visual estimates of flow rate will be made at the time of sampling.

Prior to sample collection, surface water field parameters will be measured using the methods specified in OPS-PRO.094, *Field Measurements of Surface Water Field Parameters*. Grab samples for VOC analysis of surface water will be collected by container immersion if a sufficient water depth exists for submergence, or a transfer device (i.e., dipper) for low flow conditions, in accordance with the requirements of OPS-PRO.081, *Surface Water Sampling*. All samples will be collected immediately upstream of the discharge measurement point to avoid collecting sediment suspended by channel disturbances associated with flow measurement.

4.6 Sample Handling and Analysis

Samples will be handled according to RMRS/OPS-PRO.069, *Containing, Preserving, Handling, and Shipping of Soil and Water Samples*. If necessary, a Health and Safety Specialist (HSS) or Radiological Control Technician (RCT) will scan each sample with a Field Instrument for the Detection of Low Energy Radiation (FIDLER). Equipment will also be monitored for radiological contamination during and after sampling activities, if required.

Table 4-2 indicates the analytical requirements for groundwater and surface water/seep samples for the initial characterization round of sampling. Table 4-3 indicates the requirements for natural attenuation monitoring samples (4 samples, groundwater only) to be collected at locations determined by the results of the initial sampling round as described in Section 2.0. Samples will be submitted to an offsite, Environmental Protection Agency (EPA) approved laboratory for analysis under a 30-day result turnaround time.

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Table 4-2
Analytical Requirements for Initial Groundwater, Surface Water, and Seep Samples

Analysis	Sample Type	Matrix	No. of Samples/ Event[a]	No. of Events	EPA Method	Container	Preservation	Holding Time
Target Compound List (TCL) Volatiles	Ground-water	Water	50[c,]	1	EPA 524.2	3 (three) 40 ml amber glass vials with teflon-lids	Unfiltered, cool, 4° C	14 days
Target Compound List (TCL) Volatiles	Surface Water/ Seep	Water	3[c, d]	1	EPA 524.2	3 (three) 40 ml amber glass vials with teflon-lids	Unfiltered, cool, 4° C	14 days
Rad Screen	GW/S W/ Seep	Water	44[c]	1	N/A[b]	1 (one) 125 ml poly bottle	Unfiltered	180 days

[a] Includes three duplicate and three rinsate QC samples, except for rad screens.
[b] No EPA-approved method is currently in place for radionuclide analyses. However, guidance is provided in procedures defined in Environmental Monitoring Support Laboratory (EMSL)-LV 0539-17, *Radiological and Chemical Analytical Procedures for Analysis of Environmental Samples*, March 1979.
[c] Initial characterization sampling only.
[d] Two surface water and one seep sample.

Table 4-3
Analytical Requirements for Natural Attenuation Monitoring Parameters

Analytes	Analytical Method	Media Type	Container	Preservative	Comments/Holding Time
Volatile Organic Compounds	EPA Method 524.2	Water	2 x 40 ml VOA vials - Teflon lined septa lids	Cool, 4° C, HCl	Zero head space 14 day hold time
Dissolved Methane	8015 Modified	Water	2 x 40 ml VOA vials – Teflon lined septa lids	Cool, 4 C, (optional HCl)	7 day hold time, 14 day hold time-HCl
Sulfates	EPA 375.1	Water	1 liter plastic bottle	Cool, 4° C	Sulfates, Sulfides and Alkalinity come from same bottle 28 day hold time
Sulfides	EPA 376.1	Water	1 liter plastic bottle	Cool, 4° C	Sulfates, Sulfides and Alkalinity come from same bottle 7 day hold time
Alkalinity	SW-846 310.1, 320.2	Water	1 Liter plastic bottle	Cool, 4° C	Sulfates, Sulfides and Alkalinity come from same bottle 14 day hold time
Nitrates	NO_3 = EPA 300.0, $NO_3 + NO_2$ = EPA 353.2	Water	1 liter plastic bottle	Cool, 4° C	48 day hold time
Total Organic Carbon	EPA 415.1	Water	1 liter plastic bottle	Cool, 4° C PH<2 w/HCl	28 day hold time
Chloride	EPA 300.0	Water	100 ml. Plastic bottle	None	28 day hold time
Ferrous Iron	Field Parameter	Water	---	---	---
PH	Field Parameter	Water	---	---	---
Dissolved Oxygen	Field Parameter	Water	---	---	---
Oxidation-Reduction Potential	Field Parameter	Water	---	---	---
Temperature	Field Parameter	Water	---	---	---
Conductivity	Field Parameter	Water	---	---	---

4.7 Equipment Decontamination and Waste Handling

Reusable drilling and sampling equipment will be decontaminated with Liquinox solution, and rinsed with deionized or distilled water, in accordance with procedure 4-S01-ENV-OPS-FO.03, *Field Decontamination Procedures*. Decontamination waters generated during the project will be managed according to procedure OPS-PRO.112, *Handling of Decontamination Water and Wash Water*. Geoprobe® and drilling equipment will be decontaminated following project completion using procedure OPS-PRO.070, *Decontamination of Equipment at Decontamination Facilities*.

5.0 DATA MANAGEMENT

A project field logbook will be created and maintained by the project manager or designee (rig geologist) in accordance with Site Procedure 2-S47-ER-ADM-05.14, *Use of Field Logbooks and Forms*. The logbook will include time and date of all field activities, sketch maps of sample locations, and any additional relevant information not specifically required by the SAP. The originator will legibly sign and date each logbook page. Appropriate field data forms will also be utilized when required by the operating procedures that govern the field activity. A peer reviewer will examine each completed original hard copy of data. Any modifications will be indicated in ink, and initialed and dated by the reviewer. Logbooks will be controlled through Document Control. Borehole geologic logs will be entered into the Equis Geo database for electronic storage and future applications.

Analytical data record storage for this project will be performed by KH-ASD. Sample analytical results will be delivered directly from the laboratory to KH-ASD in an Electronic Disc Deliverable (EDD) format and archived in the Soil and Water Database (SWD) as per RMRS/OPS-PRO.072, *Field Data Management.* Hard copy records of laboratory results will be obtained from KH-ASD in the event that the analytical data is unavailable in EDD or SWD at the time of report preparation. Groundwater analytical results will be compiled into a sampling and analysis report.

6.0 PROJECT ORGANIZATION

Figure 6-1 illustrates the project organization structure. The RMRS Groundwater Operations Project Manager (PM) will be responsible for maintaining data collection and management methods that are consistent with Site operations. The PM is the individual responsible for overall project execution from pre-conceptual scoping through project implementation and closeout. Other individuals assisting with the implementation of this project are the RMRS Health and Safety Supervisor who is responsible for overall compliance with and implementation of the Project Health and Safety Plan. The RMRS Quality Assurance engineer will provide the first level of oversight and support implementation of quality controls within all quality-affecting activities of the project. The RMRS Radiological Engineer is responsible for overseeing the development and implementation of and ensuring compliance with the radiological aspects of the Project Health and Safety Plan, ALARA Job Review, and approval of applicable Radiological Work Permits (RWPs).

The Field Geologist/Investigation Lead will be responsible for field data collection, documentation, directing drilling, and well installation. They will oversee the Health and Safety Specialist who will be responsible for onsite compliance with and implementation of the Project Specific Health and Safety Plan. In addition, they will also oversee sampling personnel responsible for field data collection, sample collection, and transfer of samples for analysis. Field data collections will include sampling and obtaining screening results. Documentation will require field logs and completing appropriate forms for data management and chain-of-custody shipment. The sampling crew will coordinate sample shipment for on-site and off-site analyses through the ASD personnel. The sampling personnel are responsible for verifying that chain-of-custody documents are complete and accurate before the samples are shipped to the analytical laboratories.

7.0 QUALITY ASSURANCE

All components and processes within this project will comply with the Kaiser-Hill Team QAP (KH, 1999). The QA Program is consistent with quality requirements and guidelines mandated by the EPA, Colorado Department of Public Health and Environment (CDPHE), and DOE. In general, the applicable categories of quality control are as follows:

- Quality Program;
- Training;
- Quality Improvement;

- Documents/Records;
- Work Processes;
- Design;
- Procurement;
- Inspection/Acceptance Testing;
- Management Assessments; and
- Independent Assessments.

The project manager will be in direct contact with QA to identify and address issues with the potential to affect project quality. Field sampling quality control will be conducted to ensure that data generated from all samples collected in the field for laboratory analysis represents the actual conditions in the field. The confidence levels of the data will be maintained by the collection of QC samples, including duplicate samples and equipment rinsate samples.

Duplicate samples will be collected on a frequency of one duplicate sample for every twenty real samples. Rinsate samples will be generated at a frequency of one rinsate sample for every 20 real samples collected. Data validation will be performed on 25% of the laboratory data according to the Rocky Flats ASD, Performance Assurance Group procedures. Samples will be randomly selected from adequate surface and subsurface water sample sets by ASD personnel to fulfill data validation of 25% of the total number of VOC analyses. Table 7-1 provides the QA/QC samples and frequency requirements of QA sample generation.

Table 7-1 QA/QC Sample Type, Frequency, and Quantity

Sample Type	Frequency	Comments	Quantity/Event (estimated)
Duplicate	One duplicate for each twenty real samples		4
Rinse Blank	One rinse blank for each twenty real samples	To be performed with reusable sampling equipment following decontamination procedures	4

After TechLaw Inc. performs data validation and verification (for ASD), the analytical data are electronically transmitted to SWD for data user access. Analytical data collected in support of the groundwater program are evaluated using the guidance established in the procedure RF/RMRS-98-200, *Evaluation of Data for Usability in Final Reports.* This procedure establishes the guidelines for evaluating the analytical data with respect to the PARCC parameters. The data are evaluated for the PARCC parameters as discussed below. The Data Quality Assessment will be included in the sampling and analysis report for this project.

PARCC parameters are indicators of data quality. Analytical data that are collected in support of this SAP will be evaluated using the guidance developed in procedure RF/RMRS-98-200, *Evaluation of Data for Usability in Final Reports*. This procedure establishes the guidelines for evaluating analytical data with respect to the PARCC parameters. The following paragraphs define these PARCC parameters in conjunction with this project.

Precision. The precision of a measurement is an expression of mutual agreement among duplicate measurements of the same property taken under prescribed similar conditions. Precision is a measure of the reproducibility of results and is evaluated by comparing results from field duplicate samples with results from associated real samples. Precision is evaluated quantitatively by using the following equation:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} * 100$$

C_1 = first sample result (in terms of concentration)
C_2 = duplicate sample result (in terms of concentration)

The purpose of the field duplicate samples is to evaluate the precision of the field sampling process. The acceptable RPD limits for non-radiological field duplicate measurements are $\leq$ 30% for water. At least 85% of all quality control samples are required to comply with the established precision, or RPD goals. Duplicate samples exceeding the RPD criteria indicate that samples do not comply with the DQO specifications, and require an explanation of the deficiencies.

Accuracy. Accuracy is the degree of agreement of a measurement with an accepted reference or true value and is a measure of the bias in a system. The closer the measurement to the true value, the more accurate the measurement. All analytical data are compared with the required analytical method, and detection limit with the actual method used, and its detection limit for each medium and analyte to assess the DQO compliance for accuracy.

Representativeness. Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point. Representativeness is a qualitative term that should be evaluated to determine whether samples are collected in such a manner that the resulting data appropriately reflect the contamination present. Typically the discussion of representativeness is limited to an evaluation of whether analytical results for field samples are truly representative of environmental concentration, or whether they may have been influenced by the introduction of contamination during collection and handling. This is assessed by evaluating the results of various blanks, specifically equipment rinsates. Representativeness is also accomplished by obtaining an adequate number of samples from appropriate spatial locations within the medium of interest. The actual sample types and quantities will be compared with those stated in this SAP and organized by analytical suite. Deviation from the required and actual parameters will be justified in the Data Quality Assessment.

Completeness. Completeness is a measure of the amount of valid usable data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions. Usability is determined by evaluation of the PARCC parameters excluding completeness. Those data that are validated and need no qualification, or are qualified as estimated or undetected, are considered usable. Rejected data are not considered usable. Completeness is calculated following data evaluation. A completeness goal of 90% has been established for this project. If this goal is not met, additional sampling may be necessary to adequately achieve project objectives. Completeness is calculated using the following equation:

$$Completeness = DP_u = \left[\frac{DP_t - DP_n}{DP_t}\right]100$$

Where:

	DP_u	=	Percentage of usable data points
	DP_n	=	Non usable data points
	DP_t	=	Total number of data points

Comparability. Comparability is a qualitative parameter. Consistency in the acquisition, handling, and analysis of samples is necessary for comparing results. Data developed under this investigation are collected and analyzed using standard EPA or nationally recognized analytical methods, and QC procedures to ensure comparability of results with other analyses performed in a similar manner. Data resulting from this sampling effort may be compared to other data sets. Quantitative values for the PARCC parameters are provided in Table 7-2.

Table 7-2 PARCC Parameter Summary

PARCC	Radionuclides	Non-Radionuclides
Precision	N/A	RPD ≤ 30% for VOCs
Accuracy	N/A	Comparison of Laboratory Control Sample Results with Real Sample Results
Representativeness	N/A	Based on SOPs and SAP
Comparability	N/A	Based on SOPs and SAP
Completeness	N/A	90% Useable

Laboratory validation shall be performed on 25% of the characterization data collected in support of this project. Laboratory verification shall be performed on the remaining 75% of the data. Data usability shall be performed on laboratory validated data according to procedure RF/RMRS-98-200, *Evaluation of Data for Usability in Final Reports*.

Data validation will be performed according to KH-ASD procedures, but will be done after the data is used for its intended purpose. Analytical laboratories supporting this task have all passed regular laboratory audits by KH-ASD.

8.0 SCHEDULE

Well installation activities are scheduled to be completed during calendar year 2000. Well development, groundwater sampling, and surface water sampling will commence within one week of well completions. Land surveying or GPS of well and borehole locations and elevations will be performed following the completion of all intrusive activities. Results of the investigation will be reported in a sampling and analysis report within 90 days of the receipt of laboratory analytical data.

9.0 REFERENCES

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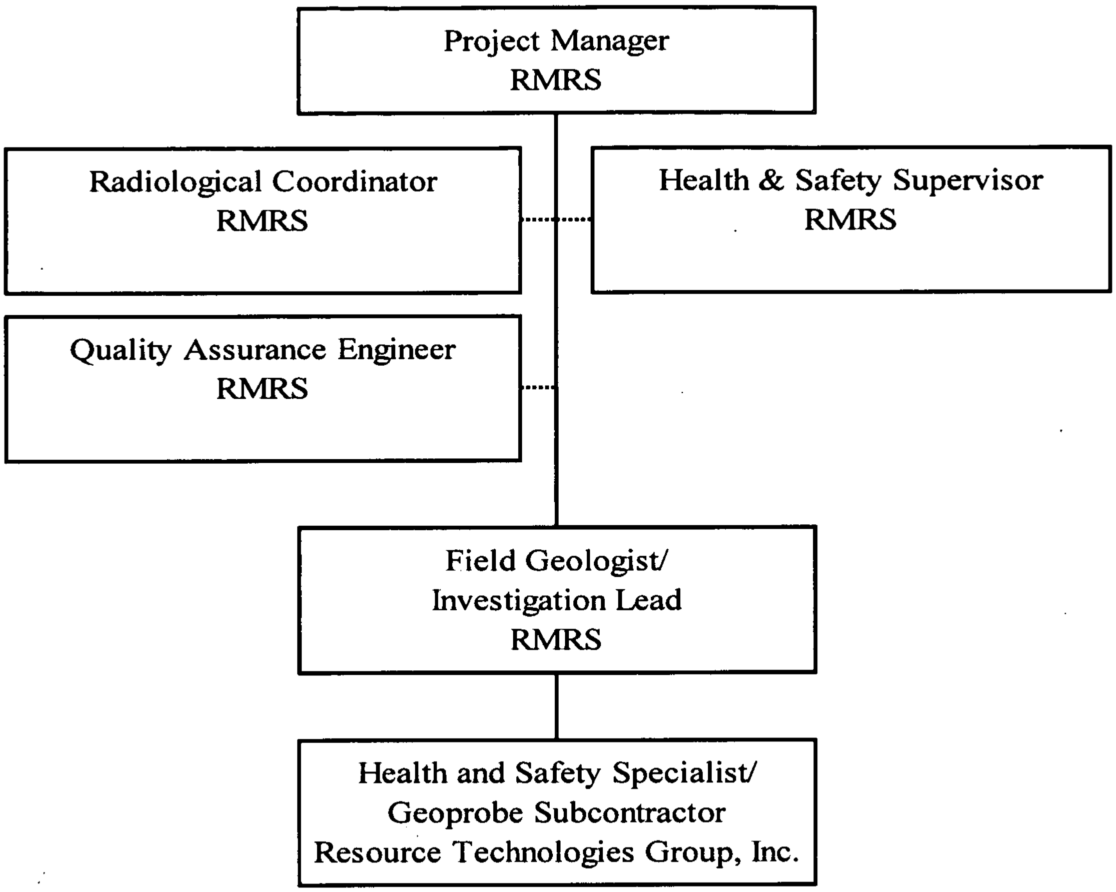
Figure 6-1
PU&D Yard Plume Groundwater Monitoring Organization Chart



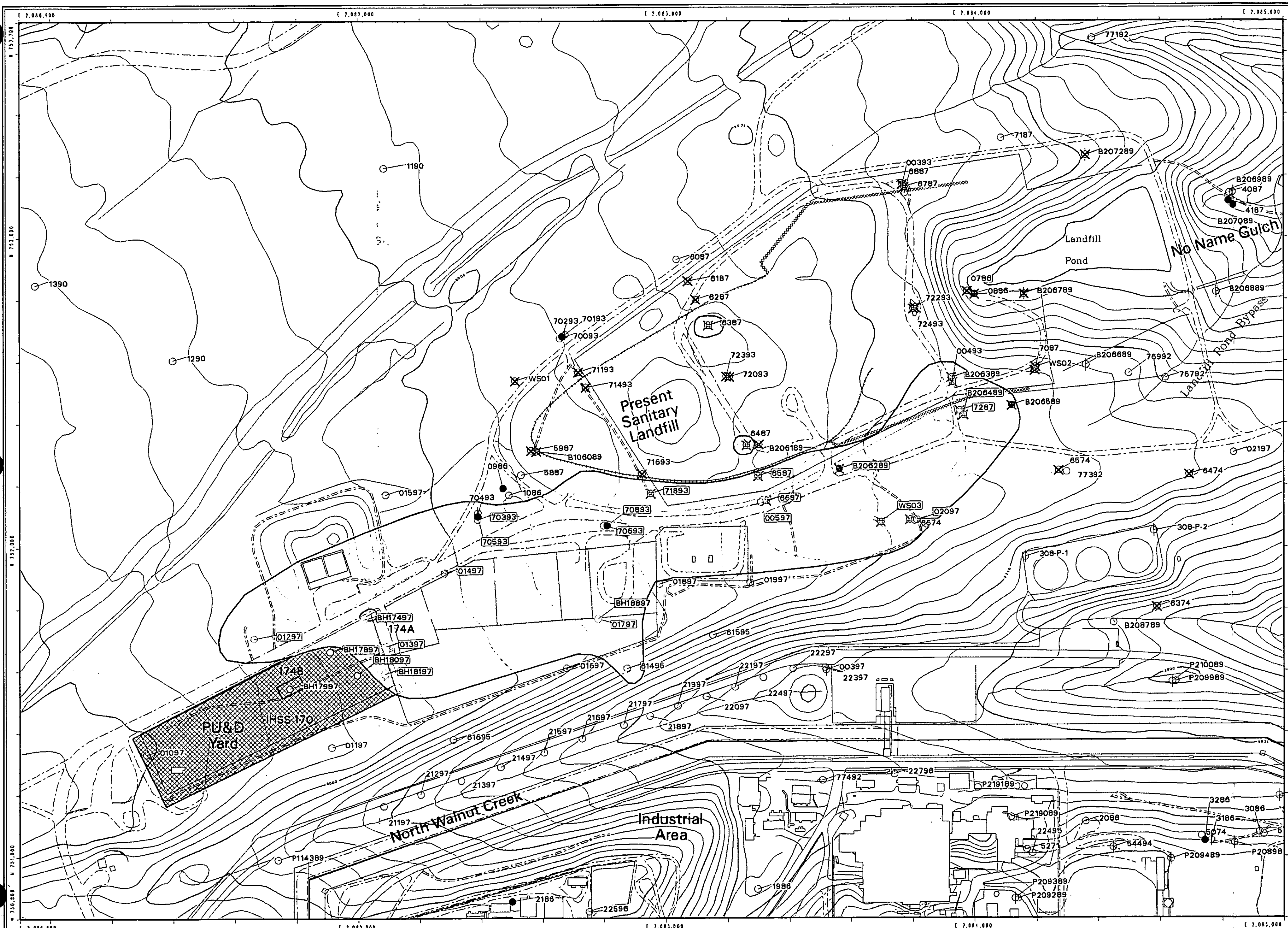


Figure 1-1
PU&D Yard
Groundwater VOC Plume
Existing and Abandoned Monitoring Wells

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Abandoned Monitor Well
- Groundwater Intercept System
- Landfill Slurry wall
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

NOTE:
Source of GIS data available upon request.

Scale = 1 : 3930
1 inch represents approximately 328 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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May 15, 2000

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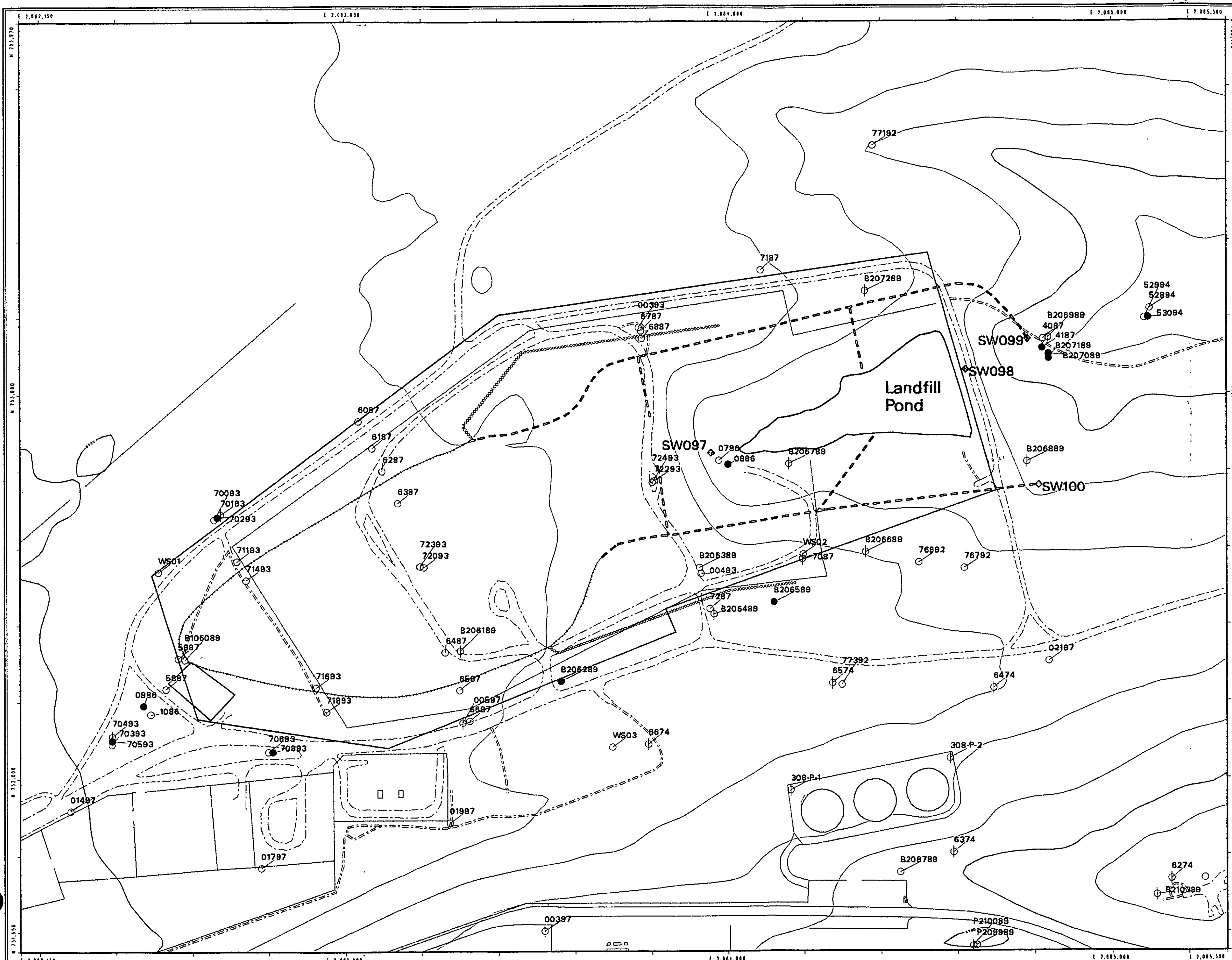
Figure 1-2
Present Sanitary Landfill Groundwater Intercept and Diversion System



EXPLANATION

- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Surface Water Monitoring Locations
- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Individual Hazardous Substance Site
- Tanks
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 3060
1 inch represents 255 feet

100 0 200 400ft

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May 05, 2000

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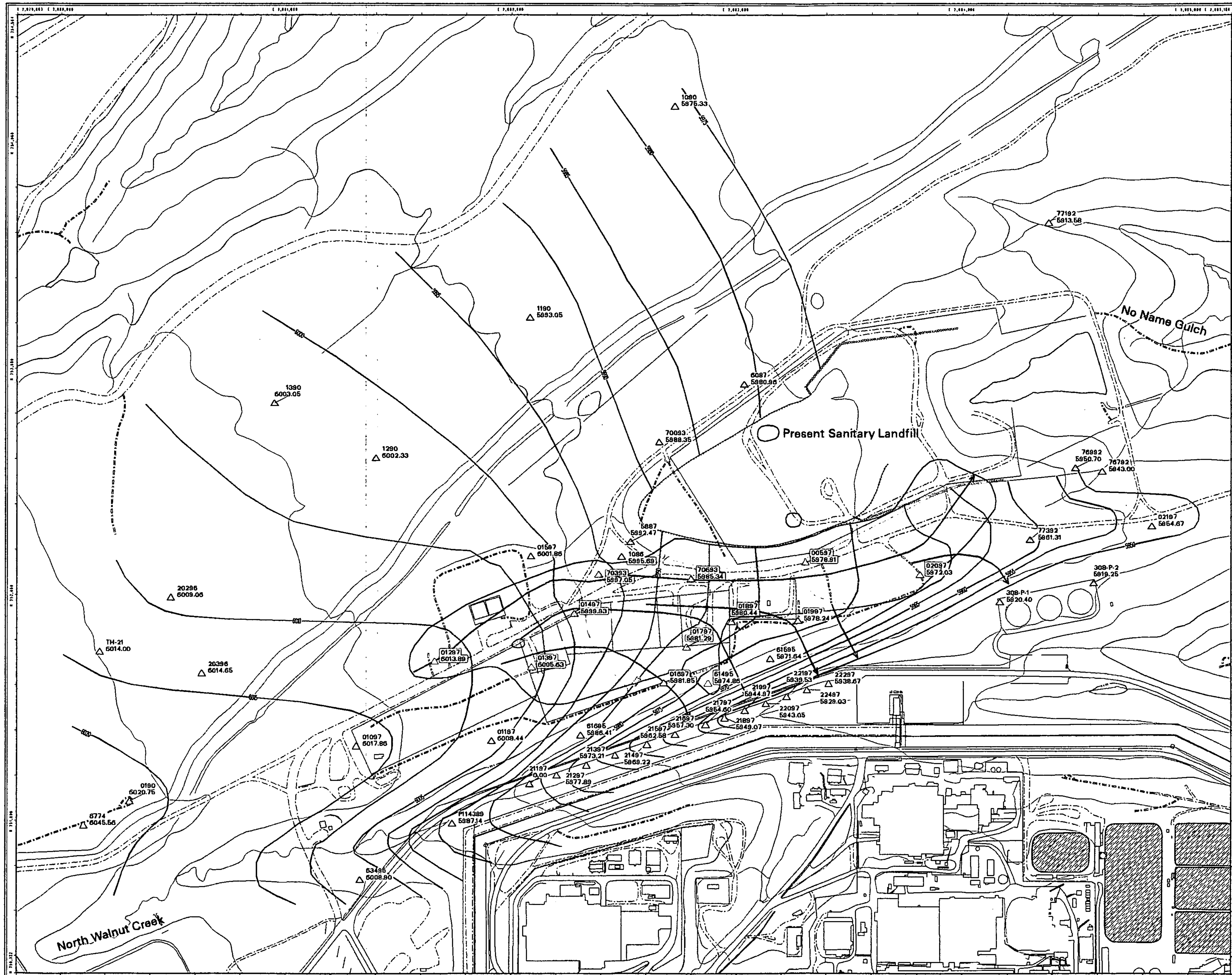

Figure 1-3

Potentiometric Surface Map of the PU&D Yard Area

May 1998

EXPLANATION

- Groundwater Well
- Groundwater Intercept System
- Landfill Slurry wall
- Water Level Contour
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- Groundwater Flow Direction Arrow

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

NOTE:
Source of GIS data available upon request.

Water Level data collected on May 8, 1998.

Scale = 1 : 5470
1 inch represents approximately 456 feet

100 0 200 400 ft

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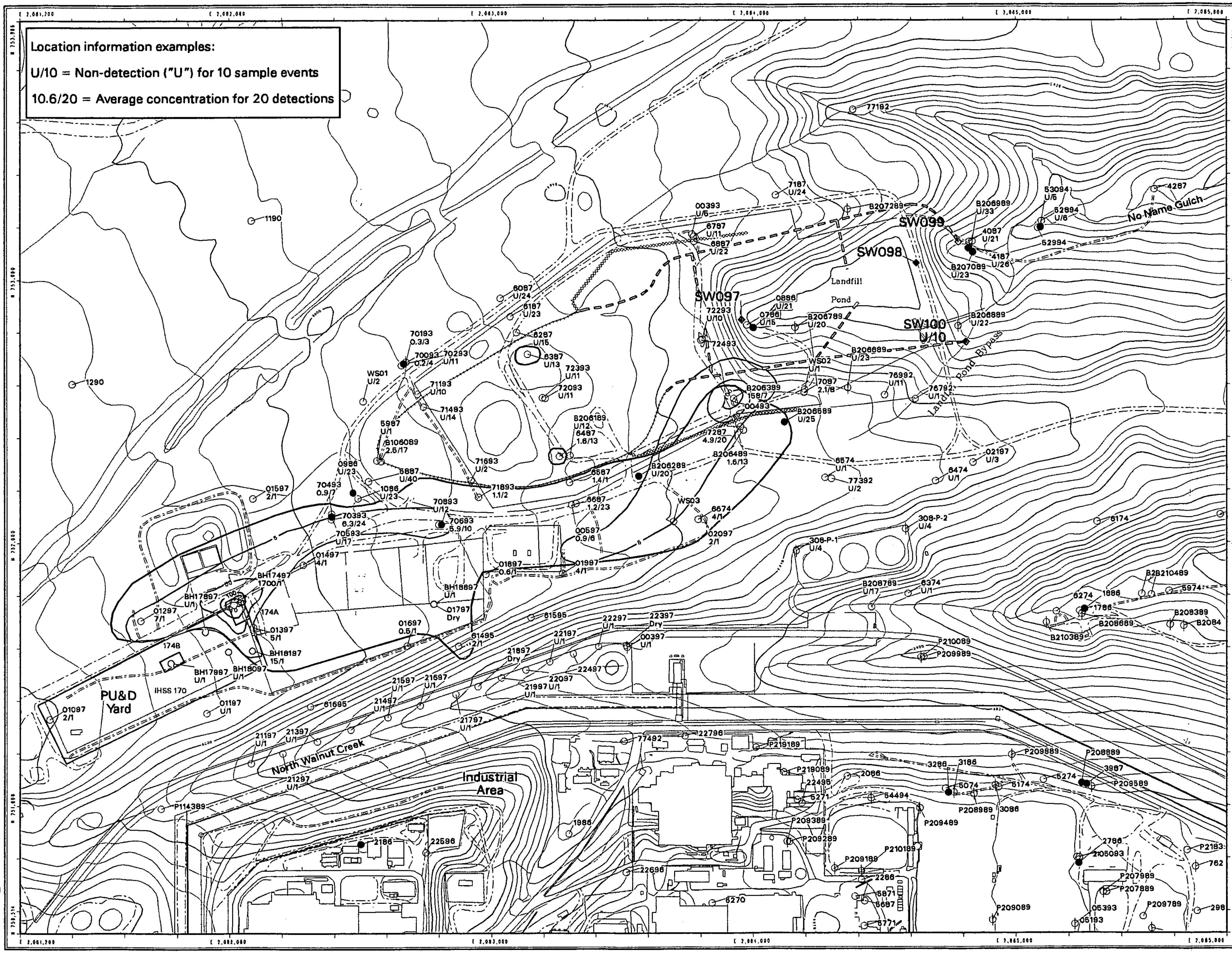

Figure 1-4
PU&D Yard Groundwater Tetrachloroethene Concentrations (ug/L)
Tier II = 5 ug/L

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Surface Water Monitoring Locations
- Groundwater Intercept System
- Landfill Slurry wall
- GW Intercept System - Non-Perforated
- Contour Intervals = 5, 50, 100, 1000 ug/L
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

N

Scale = 1 : 4480
1 inch represents approximately 373 feet

100 0 200 400 ft

State Plane Coordinate Projection
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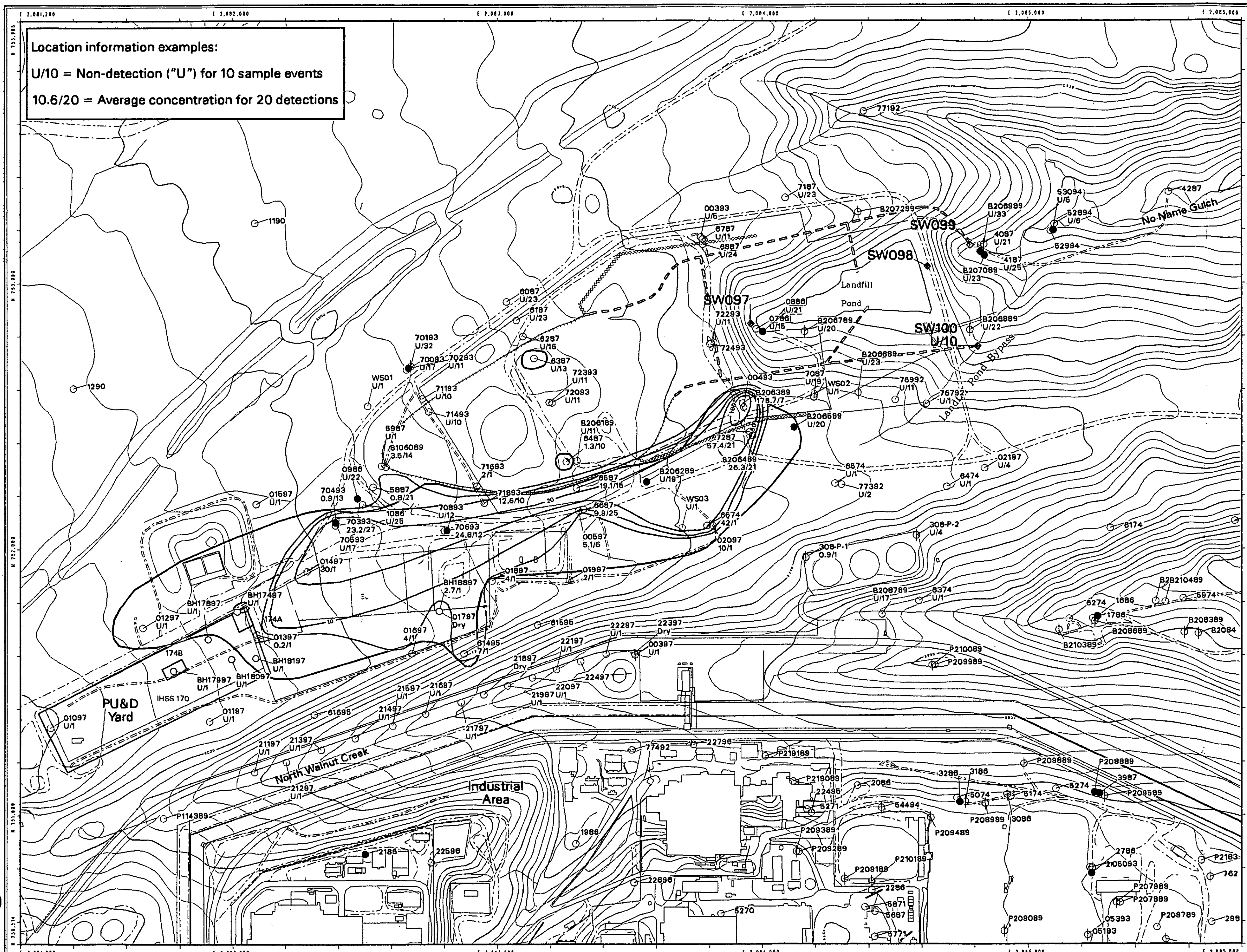

Figure 1-5

PU&D Yard Groundwater Trichloroethene Concentrations (ug/L)

Tier II = 5 ug/L

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Surface Water Monitoring Locations
- Groundwater Intercept System
- Landfill Slurry wall
- GW Intercept System - Non-Perforated
- Contour Intervals = 5, 10, 20, 50, 100 ug/L
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

N

Scale = 1 : 4480
1 inch represents approximately 373 feet

100 0 200 400 ft

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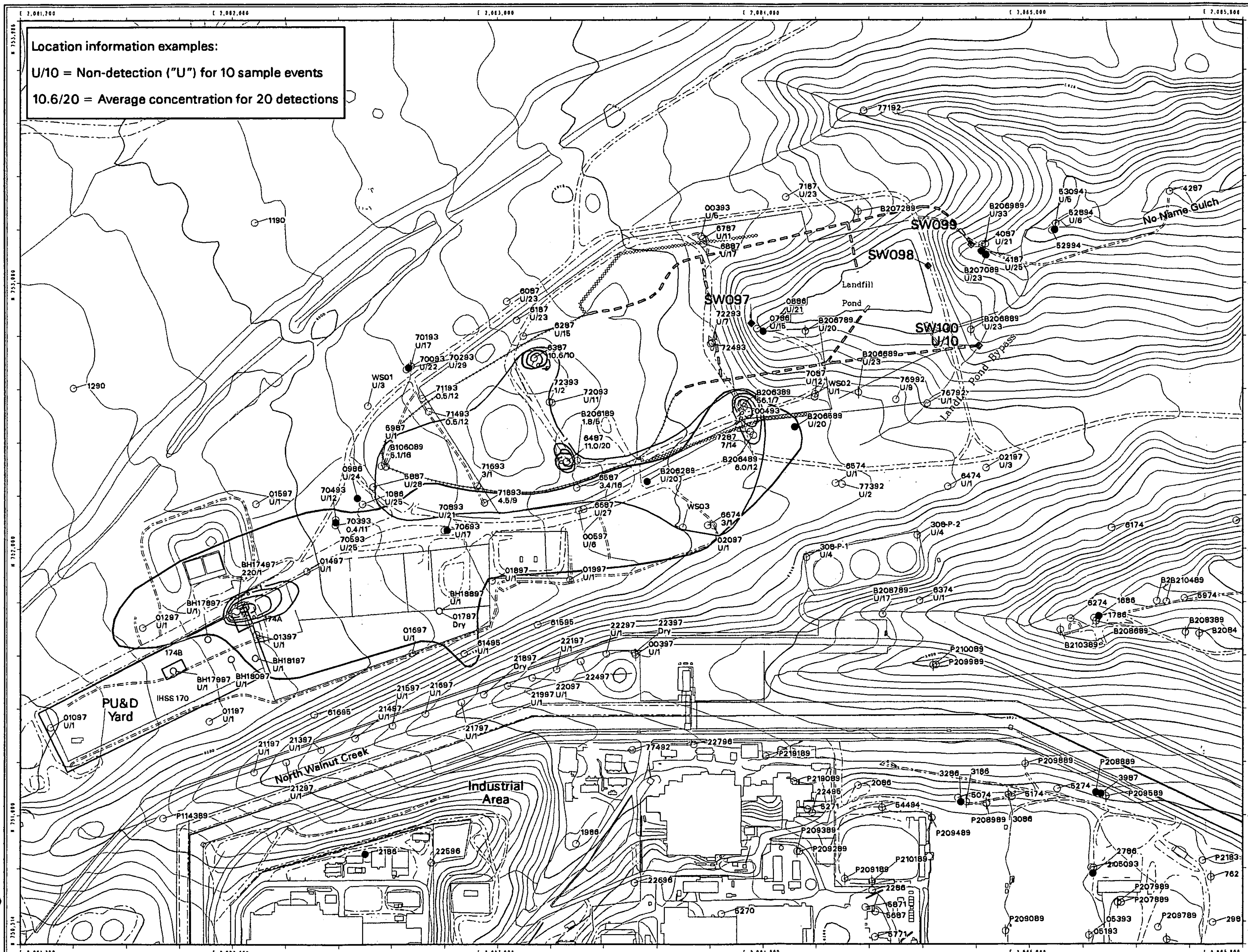

Figure 1-6

PU&D Yard Groundwater 1,2-Dichloroethene Concentrations (ug/L)

Tier II = 70 ug/L

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Surface Water Monitoring Locations
- Groundwater Intercept System
- Landfill Slurry wall
- GW Intercept System - Non-Perforated
- Contour Intervals = 1, 5, 10, 50 ug/L
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

N

Scale = 1 : 4480
1 inch represents approximately 373 feet

100 0 200 400ft

State Plane Coordinate Projection
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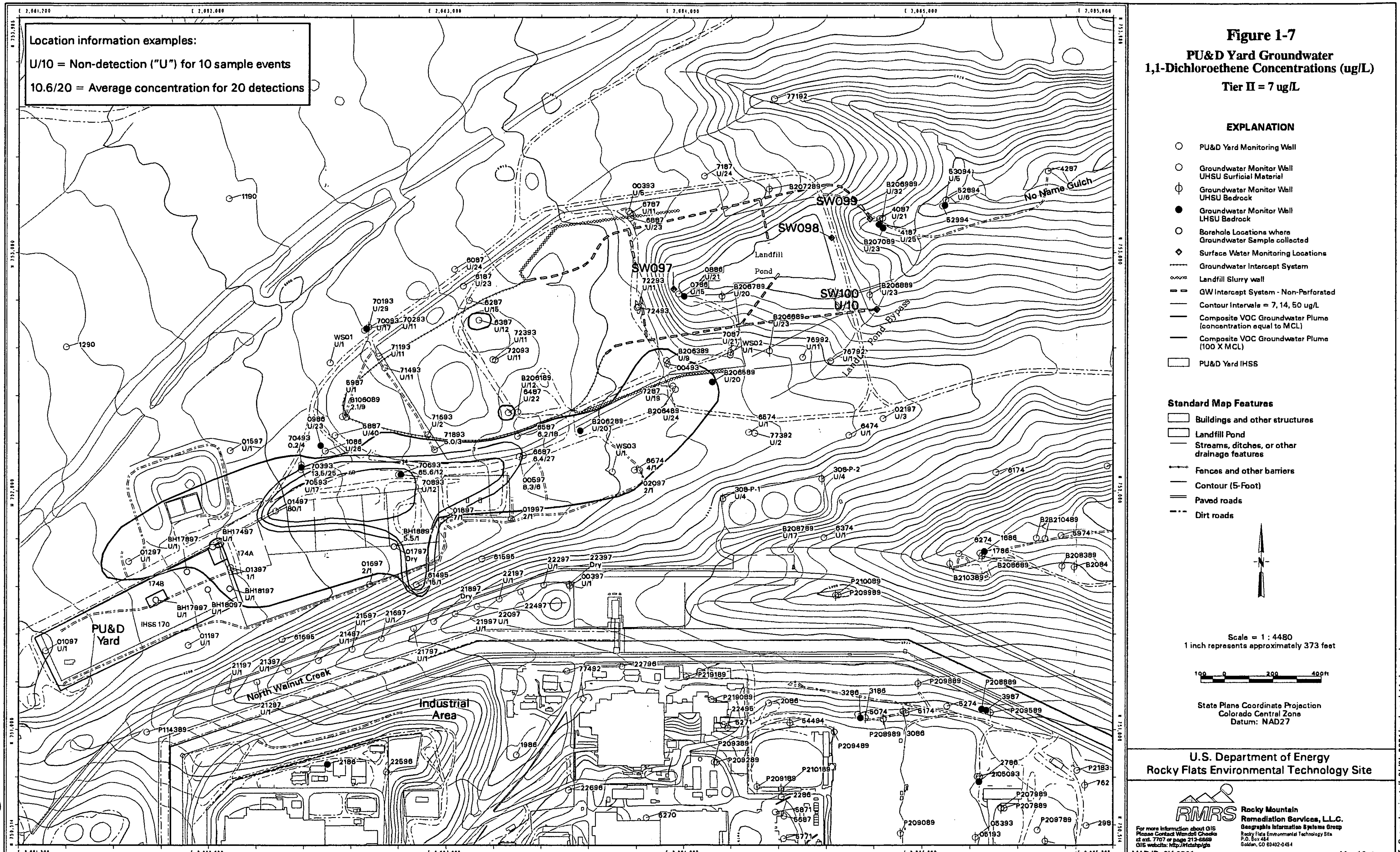
Location information examples:
U/10 = Non-detection ("U") for 10 sample events
10.6/20 = Average concentration for 20 detections
Figure 1-7
PU&D Yard Groundwater
1,1-Dichloroethene Concentrations (ug/L)
Tier II = 7 ug/L
EXPLANATION
PU&D Yard Monitoring Well
Groundwater Monitor Well UHSU Surficial Material
Groundwater Monitor Well UHSU Bedrock
Groundwater Monitor Well LHSU Bedrock
Borehole Locations where Groundwater Sample collected
Surface Water Monitoring Locations
Groundwater Intercept System
Landfill Slurry wall
GW Intercept System - Non-Perforated
Contour Intervals = 7, 14, 50 ug/L
Composite VOC Groundwater Plume (concentration equal to MCL)
Composite VOC Groundwater Plume (100 X MCL)
PU&D Yard IHSS
Standard Map Features
Buildings and other structures
Landfill Pond
Streams, ditches, or other drainage features
Fences and other barriers
Contour (5-Foot)
Paved roads
Dirt roads
Scale = 1 : 4480
1 inch represents approximately 373 feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
RMRS Rocky Mountain Remediation Services, L.L.C.
MAP ID: 2K-0201
May 16, 2000
PU&D Yard
IHSS 170
North Walnut Creek
Industrial Area
Landfill Pond
No Name Gulch
SW097
SW098
SW099
SW100 U/10

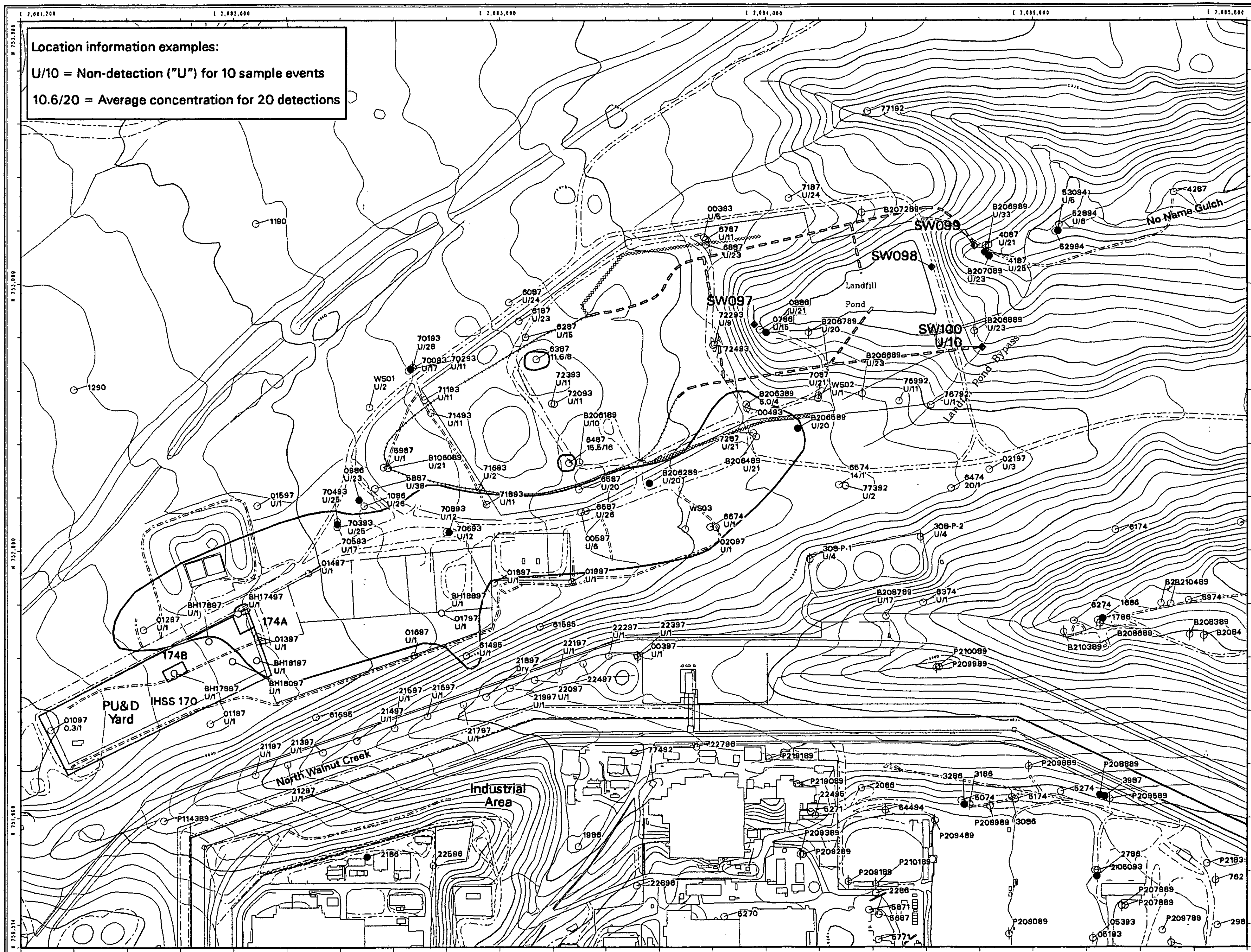

Figure 1-8

PU&D Yard Groundwater Vinyl Chloride Concentrations (ug/L)

Tier II = 2 ug/L

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Surface Water Monitoring Locations
- Groundwater Intercept System
- Landfill Slurry wall
- GW Intercept System - Non-Perforated
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

N

Scale = 1 : 4480
1 inch represents approximately 373 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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Geographic Information Systems Group
Rocky Flats Environmental Technology Site
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Golden, CO 80402-0464

For more information about GIS
Please Contact Wendell Checks
at ext. 7707 or page 212-6869
GIS website: http://hlctshp/gis

MAP ID: 2K-0201

May 16, 2000

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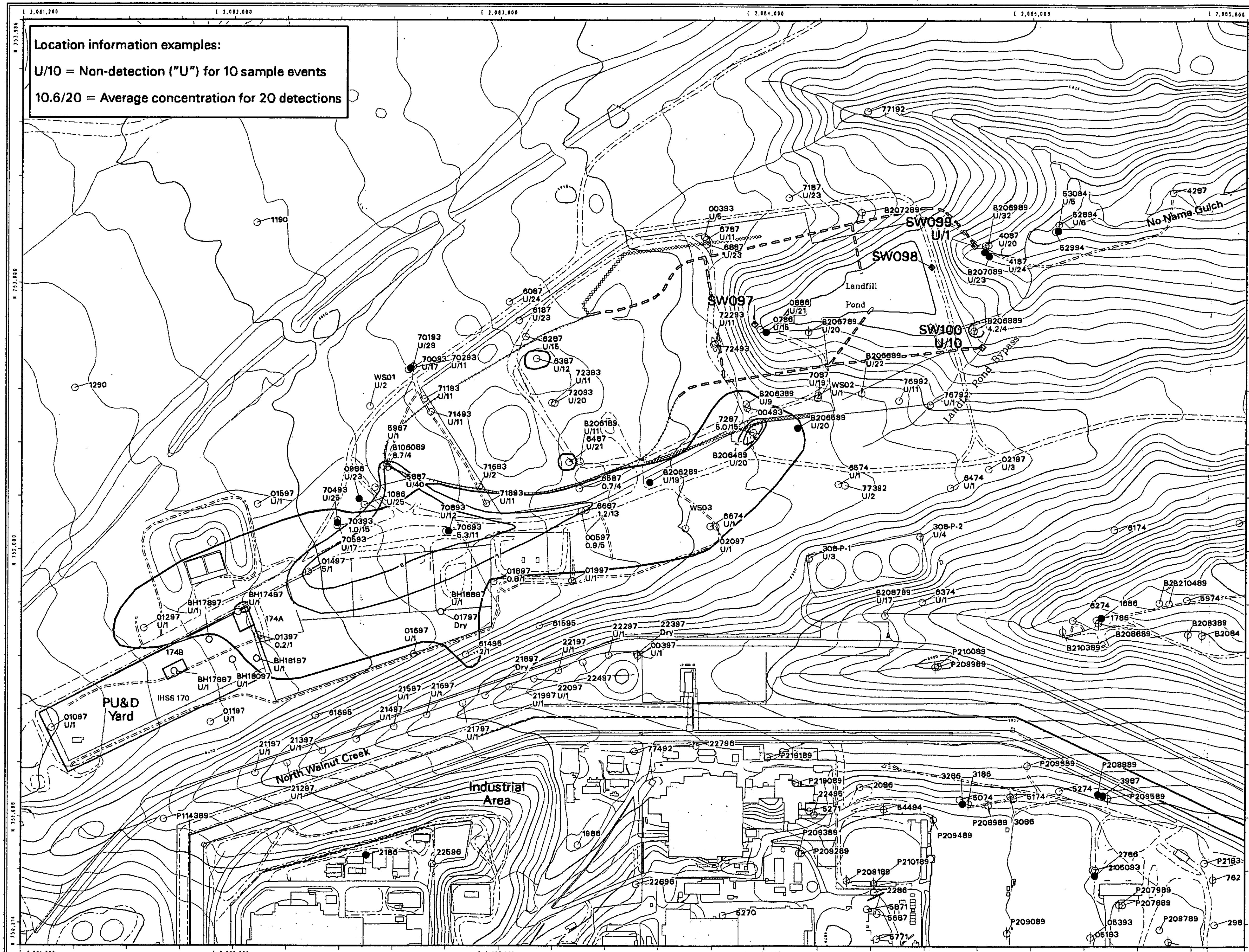

Figure 1-9

PU&D Yard Groundwater Carbon Tetrachloride Concentrations (ug/L)

Tier II = 5 ug/L

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Surface Water Monitoring Locations
- Groundwater Intercept System
- Landfill Slurry wall
- GW Intercept System - Non-Perforated
- Contour Intervals = 1, 5 ug/L
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 4480
1 inch represents approximately 373 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 2K-0201

May 16, 2000

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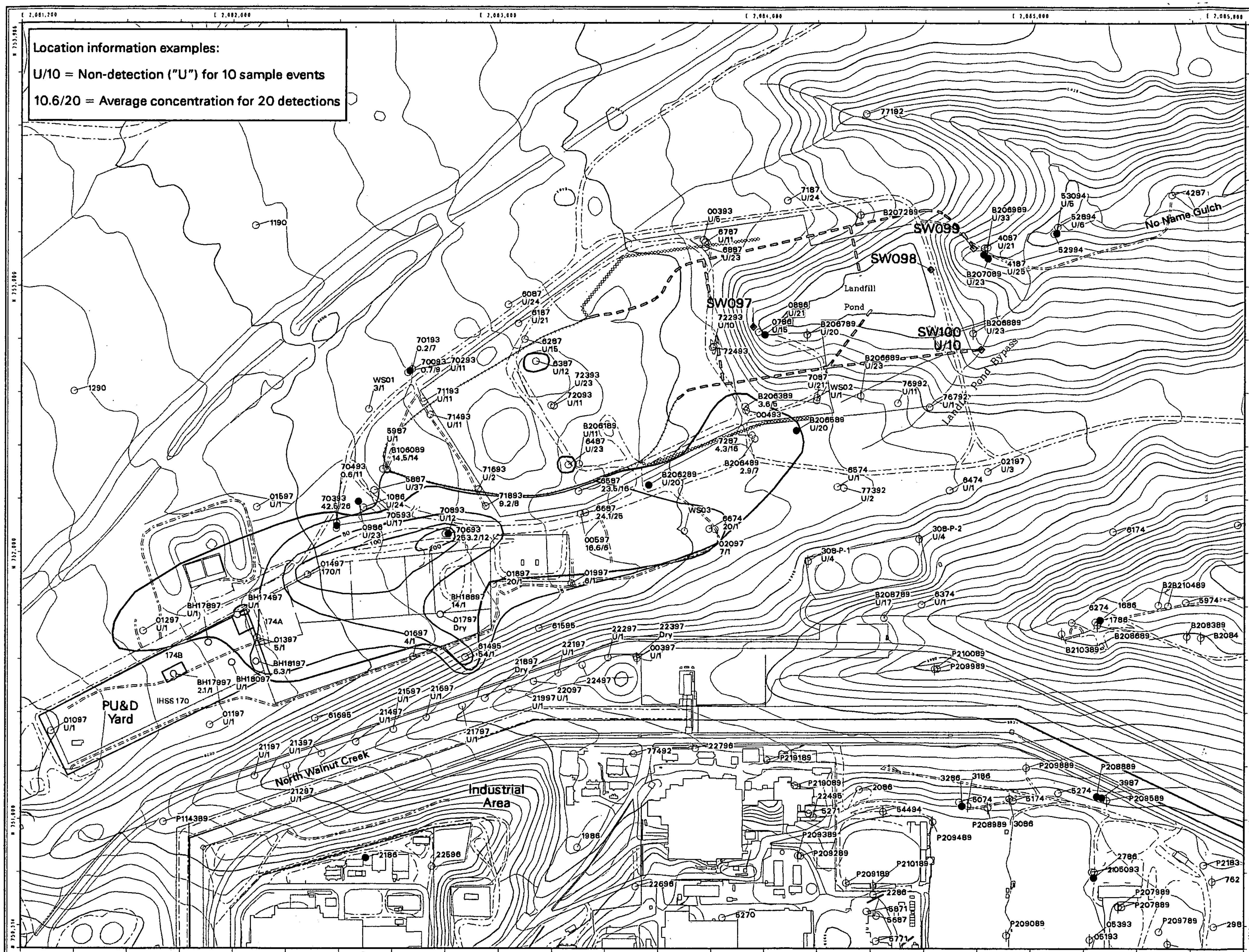

Figure 1-10

PU&D Yard Groundwater 1,1,1-Trichloroethane Concentrations (ug/L)

Tier II = 200 ug/L

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations where Groundwater Sample collected
- Surface Water Monitoring Locations
- Groundwater Intercept System
- Landfill Slurry wall
- GW Intercept System - Non-Perforated
- Contour Intervals = 5, 50, 100, 200 ug/L
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 4480
1 inch represents approximately 373 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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May 16, 2000

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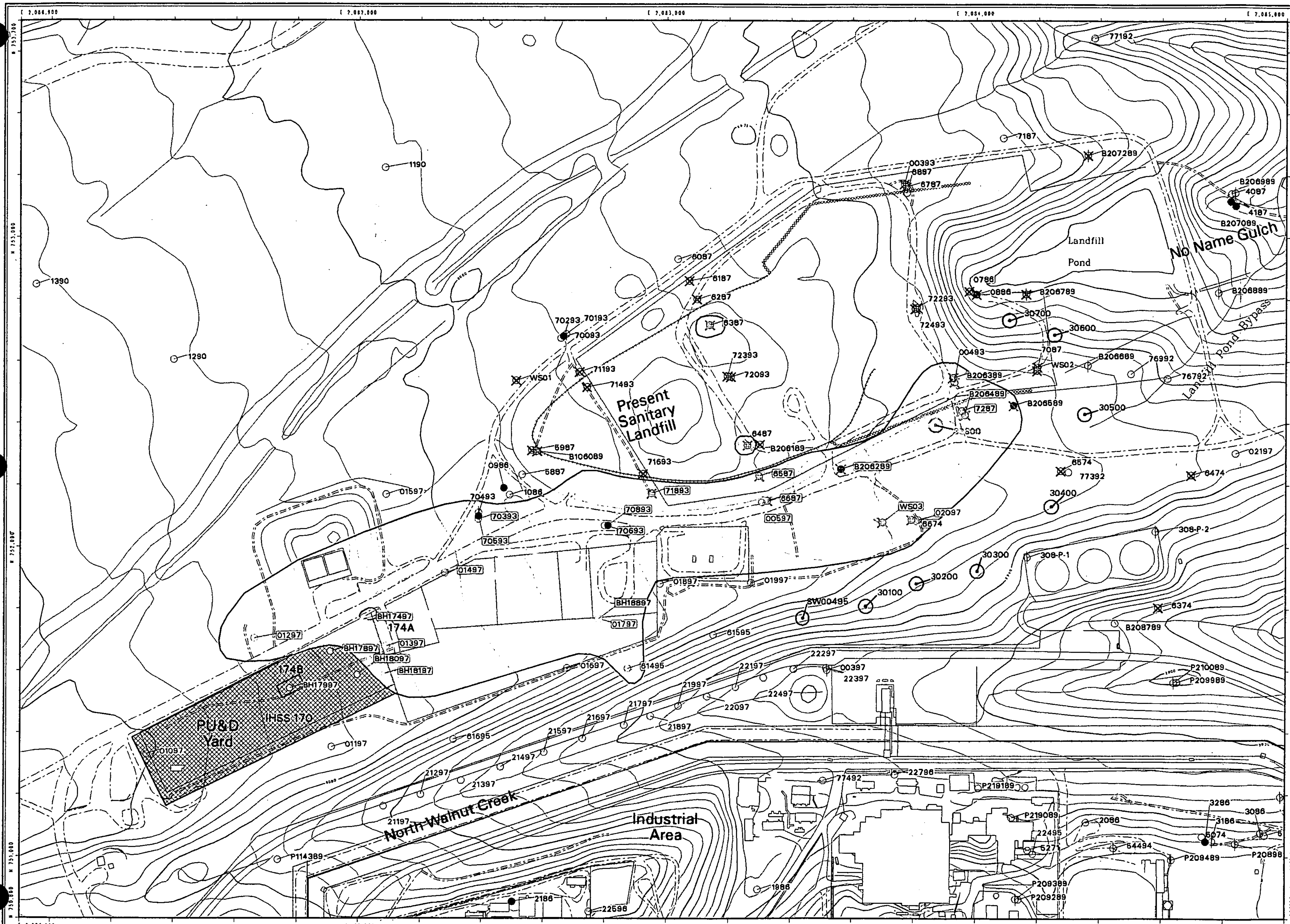

Figure 4-1
PU&D Yard
Groundwater VOC Plume
Location of Proposed Monitoring Wells

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations
- Abandoned Monitor Well
- Proposed PU&D Yard VOC Plume Monitoring Well and Temporary Monitoring Well
- Groundwater Intercept System
- Landfill Slurry wall
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

NOTE:
Source of GIS data available upon request.

Scale = 1 : 3930
1 inch represents approximately 328 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 2K-0201

May 16, 2000

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